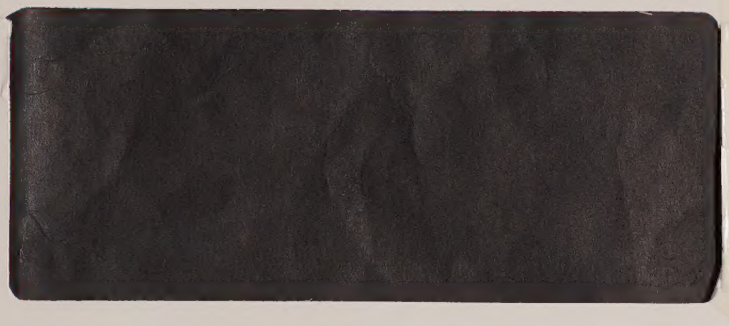
OPERATING AND SERVICE MANUAL



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CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

OPERATING AND SERVICE MANUAL

MODEL 6434B

DC POWER SUPPLY

SERIAL NUMBER PREFIX 7G

Printed: December, 1967
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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

BEFORE APPLYING POWER.

Verify that the product is set to match the available line voltage and the correct fuse is installed.

GROUND THE INSTRUMENT.

This product is a Safety Class 1 instrument (provided with a protective earth terminal). To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument must be connected to the ac power supply mains through a three-conductor power cable, with the third wire firmly connected to an electrical ground (safety ground) at the power outlet. For instruments designed to be hard-wired to the ac power lines (supply mains), connect the protective earth terminal to a protective conductor before any other connection is made. Any interruption of the protective (grounding) conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury. If the instrument is to be energized via an external autotransformer for voltage reduction, be certain that the autotransformer common terminal is connected to the neutral (earthed pole) of the ac power lines (supply mains).

INPUT POWER MUST BE SWITCH CONNECTED.

For instruments without a built-in line switch, the input power lines must contain a switch or another adequate means for disconnecting the instrument from the ac power lines (supply mains).

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE.

Do not operate the instrument in the presence of flammable gases or fumes.

KEEP AWAY FROM LIVE CIRCUITS.

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power, discharge circuits and remove external voltage sources before touching components.

DO NOT SERVICE OR ADJUST ALONE.

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT EXCEED INPUT RATINGS.

This instrument may be equipped with a line filter to reduce electromagnetic interference and must be connected to a properly grounded receptacle to minimize electric shock hazard. Operation at line voltages or frequencies in excess of those stated on the data plate may cause leakage currents in excess of 5.0 mA peak.

SAFETY SYMBOLS.

Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual (refer to Table of Contents).

Indicates hazardous voltages.

or ⊥ Indicate earth (ground) terminal.

WARNING

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

CAUTION

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

Instruments which appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

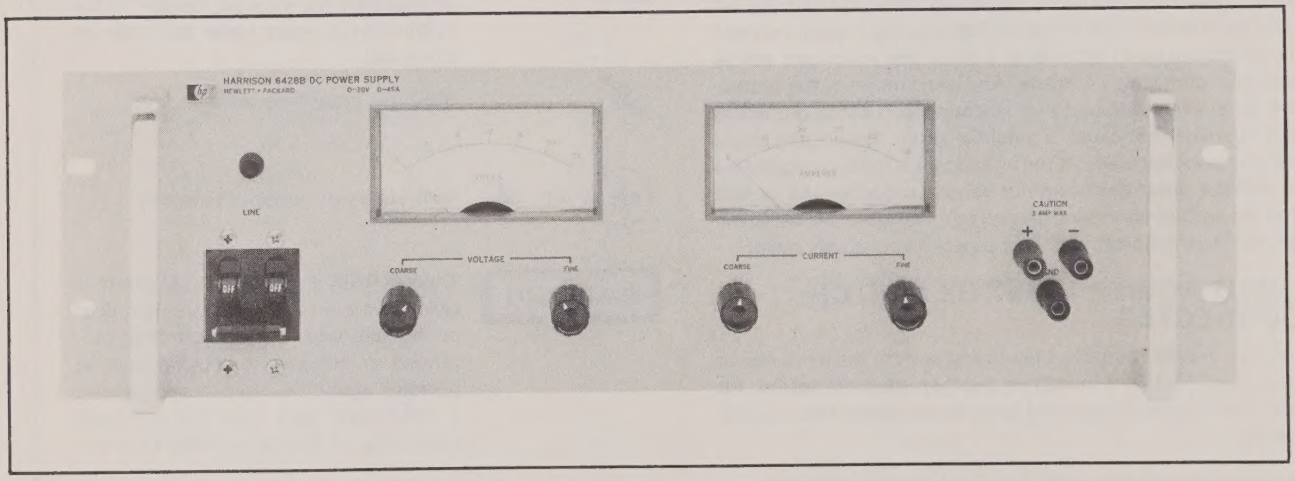


Figure 1-1. DC Power Supply, SCR-1P Series

SECTION I
GENERAL INFORMATION

1-1 DESCRIPTION

1-2 Model 6434B DC Power Supply (Figure 1-1) is a completely solid-state, compact, well-regulated, constant voltage/constant current dc power supply suitable for either bench or relay rack operation. Input power is connected to a terminal strip at the rear of the power supply. The output is continuously variable between 0 and 40Vdc, and between 0 and 25 Amperes. Detailed specifications are given in Table 1-1.

1-3 OVERLOAD PROTECTION

1-4 A crossover feature protects both power supply and load in constant voltage operation. Automatic crossover circuitry switches the power supply from constant voltage to constant current operation if the output current exceeds a preset limit. This crossover circuitry also protects the load from overvoltage during constant current operation by automatically switching the power supply into constant voltage operation. The user can adjust the crossover point via the front panel controls (Paragraphs 3-7 and 3-8).

1-5 The power supply is protected from reverse voltage (positive voltage applied to negative terminal) by a diode that shunts current across the output terminals when this condition exists. The ac input components are protected by a dual circuit breaker in the ac input line. This circuit breaker is located on the front panel and serves as the on/off switch.

1-6 COOLING

1-7 A fan is used to blow air from left to right (facing front panel) through a compartment containing the major heat producing elements.

1-8 MONITORING

1-9 Two front-panel meters are provided for monitoring output voltage and current. The voltmeter has a 0 to 50 Volt range and the ammeter has a 0 to 30 Ampere range. Each meter has a 2% accuracy at full scale.

1-10 OUTPUT TERMINALS

1-11 Output power is available via a terminal strip on the rear panel. The rear panel terminal strip also enables the power supply to be connected for different modes of operation (Paragraph 3-3). The output terminals are isolated from the chassis and either the positive or the negative terminal may be connected to the chassis via a separate ground terminal located adjacent to the output terminals. The power supply is insulated to permit operation up to 300Vdc off ground.

1-12 INSTRUMENT IDENTIFICATION

1-13 Hewlett-Packard power supplies are identified by a three-part serial number tag. The first part is the power supply model number. The second part is the serial number prefix, which consists of a number-letter combination that denotes the date of a significant design change. The number designates the year, and the letter A through L designates the month, January through December respectively. The third part is the power supply serial number.

1-14 If the serial number prefix on your power supply does not agree with the prefix on the title page of this manual, change sheets are included to update the manual. Where applicable, backdating information is given in an appendix at the rear of the manual.

1-15 ORDERING ADDITIONAL MANUALS

1-16 One manual is shipped with each power supply. Additional manuals may be purchased from your local Hewlett-Packard field office (see list at rear of this manual for addresses). Specify the model number, serial number prefix, and hp stock number provided on the title page.

Table 1-1. Specifications

INPUT:
115Vac ±10%, 57 to 63Hz, single phase, 19 Amperes, 1300 Watts max.

RATED OUTPUT:
Constant Voltage: 0 to 40Vdc
Constant Current: 0 to 25 Amperes dc

LINE REGULATION:
Constant Voltage: Less than 18mV for 10% change in the nominal input voltage.
Constant Current: Less than 200mA for 10% change in the nominal line voltage.

LOAD REGULATION:
Constant Voltage: Less than 40mV for 0 to 25 Ampere load change.
Constant Current: Less than 200mA for 0 to 40Vdc load change.

RIPPLE AND NOISE:
40mVrms

OPERATING TEMPERATURE RANGE:
0°C to 55°C

STORAGE TEMPERATURE RANGE:
-40°C to +75°C

TEMPERATURE COEFFICIENT:
Constant Voltage: 0.03% plus 5mV per degree centigrade.
Constant Current: 75mA per degree centigrade.

OUTPUT STABILITY:
(after 30-minute warm-up)
Constant Voltage: 0.1% plus 20mV for 8 hours at constant temperature.
Constant Current: 250mA for 8 hours at constant temperature.

REMOTE PROGRAMMING:
Constant Voltage: 200 ohms per Volt ±1%.
Constant Current: 10 ohms per Ampere ±10%.

TYPICAL OUTPUT IMPEDANCE:
Less than 0.01 ohm from dc to 0.5Hz.
Less than 0.5 ohm from 0.5Hz to 100Hz.
Less than 0.1 ohm from 100Hz to 1kHz.
Less than 0.6 ohm from 1kHz to 100kHz.

OUTPUT INDUCTANCE:
1.0 microhenry

TRANSIENT RECOVERY TIME:
In constant voltage operation, less than 200 milliseconds is required for output voltage recovery to within 200 millivolts of the nominal output voltage following a load change equal to one half the maximum current rating of the power supply. Nominal output voltage is defined as the mean between the no-load and full-load voltages. The transient amplitude is less than 0.3 Volt per Ampere for any load change between 20% and 100% of rated output current. (Excluding the initial spike of approximately 100 microseconds duration which is significant only for load rise times faster than 0.1 Ampere per microsecond.)

SIZE AND WEIGHT:
5-1/4 in. H x 19 in. W x 16-3/4 in. D, 67 lbs.

FINISH:
Light gray front panel with dark gray case.

SECTION II
INSTALLATION

2-1 INITIAL INSPECTION

2-2 Before shipment, the power supply was inspected and found free of mechanical and electrical defects. As soon as the power supply is unpacked, inspect it for any damage that may have occurred in transit. Also check the cushioning material for signs of severe stress (may be indication of internal damage). Save all packing materials until the inspection is completed. If damage is found, proceed as instructed in the Claim for Damage in Shipment notice on the back of the front cover of this manual.

2-3 MECHANICAL CHECK

2-4 Check that there are no broken knobs or connectors, that the external surface is not scratched or dented, that the meter faces are not damaged, and that all controls move freely. Any external damage may be an indication of internal damage.

2-5 ELECTRICAL CHECK

2-6 Check that the straps on the terminal strip at the rear of the power supply are secure and that the strapping pattern is in accord with Figure 3-2. Check the electrical performance of the power supply as soon as possible after receipt. A performance check that is suitable for incoming inspection is given in Paragraphs 5-7 through 5-22.

2-7 INSTALLATION DATA

2-8 The power supply is shipped ready for bench or relay rack (19 inch) operation.

2-9 LOCATION

2-10 Because the power supply is forced-air (fan) cooled, the air intake and outlet vents on the sides of the chassis must not be obstructed. The power supply should be located in an area where ambient temperature does not exceed 55°C.

2-11 POWER REQUIREMENTS

2-12 The power supply is operated from a 115Vac ±10%, 57 to 63Hz, single phase power source. At 115 Volts, 60Hz, the full load requirement is 1300 Watts at 19 Amperes.

2-13 POWER CABLE

2-14 To protect operating personnel, the National Electrical Manufacturers Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument should be used with a three-conductor power cable that has #12 AWG wire. The third conductor is the ground conductor and when the cable is plugged into an appropriate receptacle, the instrument is grounded. The offset pin on the power cable three-prong connector is the ground connection.

2-15 To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adaptor and connect the green lead on the adaptor to ground.

2-16 REPACKAGING FOR SHIPMENT

2-17 To insure safe shipment of the instrument, it is recommended that the package designed for the instrument be used. The original packaging is reusable. If it is not available, contact your Hewlett-Packard field office for packing materials and information. A packing carton part number is included in the parts list.

2-18 Attach a tag to the instrument which specifies the owner, model number, full serial number, and service required, or a brief description of the trouble.

SECTION III
OPERATING INSTRUCTIONS

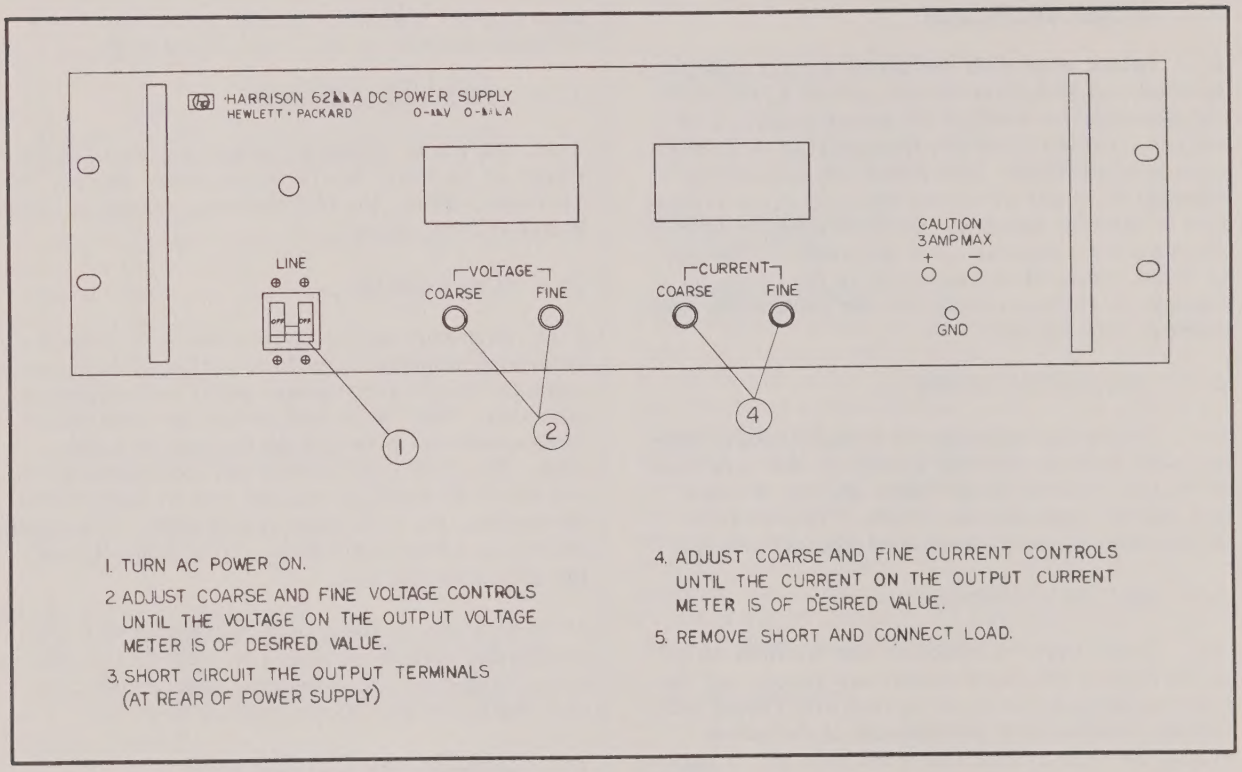


Figure 3-1. Front Panel Controls and Indicators

3-1 CONTROLS AND INDICATORS

3-2 The controls and indicators are illustrated in Figure 3-1.

3-3 OPERATION

3-4 The power supply is designed so that its mode of operation can be selected by making strapping connections between particular terminals on the terminal strip at the rear of the power supply. The terminal designations are stenciled in white on the power supply and are adjacent to their respective terminals. The strapping patterns illustrated in this section show neither terminal grounded. The operator can ground either terminal or operate the power supply up to 300Vdc off ground (floating). The ac input power is connected to the AC, ACC, and GND terminals at the rear of the power supply.

3-5 NORMAL

3-6 The power supply is normally shipped with its rear terminal strapping connections arranged for constant voltage/constant current, local sensing, local programming, single unit mode of operation. This strapping pattern is illustrated in Figure 3-2. The operator selects either a constant voltage or a constant current output using the front panel controls (local programming, no strapping changes are necessary).

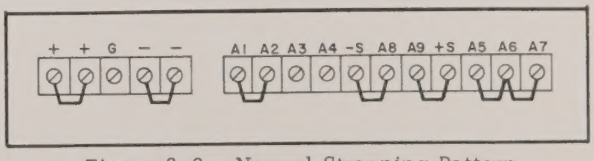


Figure 3-2. Normal Strapping Pattern

3-7 CONSTANT VOLTAGE. To select a constant voltage output, proceed as follows:

a. Turn-on power supply and adjust VOLTAGE controls for desired output voltage (output terminals open).

b. Short output terminals and adjust CURRENT controls for maximum output current allowable (current limit), as determined by load conditions. If a load change causes the current limit to be exceeded, the power supply will automatically crossover to constant current output at the preset current limit and the output voltage will drop proportionately. In setting the current limit, allowance must be made for high peak currents which can cause unwanted crossover (refer to Paragraph 3-39).

3-8 CONSTANT CURRENT. To select a constant current output, proceed as follows:

a. Short output terminals and adjust CURRENT controls for desired output current.

b. Open output terminals and adjust VOLTAGE controls for maximum output voltage allowable (voltage limit), as determined by load conditions. If a load change causes the voltage limit to be exceeded, the power supply will automatically crossover to constant voltage output at the preset voltage limit and the output current will drop proportionately. In setting the voltage limit, allowance must be made for high peak voltages which can cause unwanted crossover. (Refer to Paragraph 3-39.)

3-9 CONNECTING LOAD

3-10 Two pairs of output terminals are provided on the terminal strip at the left rear side (facing rear) of the power supply. Either pair of terminals or both may be used. The terminals are marked + and -. A separate ground terminal is located adjacent to the output terminals. The positive or negative output terminal may be grounded, or neither grounded (floating operation; permitted to 300Vdc off ground).

3-11 Each load should be connected to the power supply output terminals using separate pairs of connecting wires. This will minimize mutual coupling effects between loads and will retain full advantage of the low output impedance of the power supply. Each pair of connecting wires should be as short as possible and twisted or shielded to reduce noise pickup. (If shield is used, connect one end to power supply ground terminal and leave the other end unconnected.)

3-12 If load considerations require that the output power distribution terminals be remotely located from the power supply, then the power supply output terminals should be connected to the remote distribution terminals via a pair of twisted or shielded wires and each load separately connected to the remote distribution terminals. For this case, remote sensing should be used (Paragraph 3-13).

NOTE

It is recommended that the voltage drop in the connecting wires not exceed 2 Volts. If a larger drop must be tolerated, please consult a Hewlett-Packard field representative.

3-13 REMOTE SENSING

3-14 Remote sensing is used to ameliorate the degradation of regulation which will occur at the load when the voltage drop in the connecting wires is appreciable. The use of remote distribution terminals (Paragraph 3-12) is an example where remote sensing may be required. Due to the voltage drop in the load leads, it may be necessary to slightly increase the current limit in constant voltage operation.

CAUTION

Turn-off power supply before rearranging strapping pattern at the power supply rear terminal strip. If the -S terminal is opened while the power supply is on, the output voltage and current may exceed their maximum ratings and result in damage to the load. The power supply will not be damaged.

3-15 Proceed as follows:

a. Turn-off power supply and arrange rear terminal strapping pattern as shown in Figure 3-3. The sensing wires will carry less than 10mA and need not be as heavy as the load wires. It is recommended that sensing and load wires be twisted and shielded. (If shield is used, connect one end to power supply negative terminal and leave the other end unconnected.)

CAUTION

Observe polarity when connecting the sensing leads to the load.

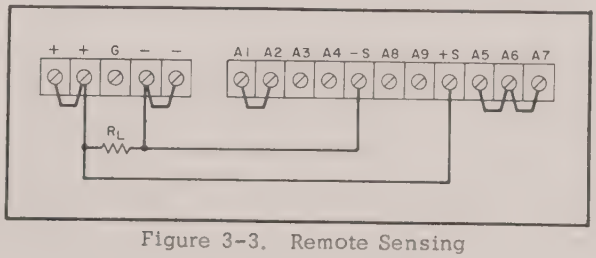


Figure 3-3. Remote Sensing

b. In order to maintain low ac output impedance, a capacitor with a minimum rating of 20,000μfd and 40 VdcW should be connected across the load using short leads. This capacitor must have high-frequency characteristics as good or better than C17 has (see parts list).

c. Turn-on power supply.

3-16 REMOTE PROGRAMMING

3-17 The constant voltage and constant current outputs may be programmed (controlled) from a remote location. The front-panel controls are disabled in the following instructions. Changes in the rear terminal strapping arrangement are necessary. The wires connecting the programming terminals of the power supply to the remote programming device should be twisted or shielded to reduce noise pick-up. (If shield is used, connect one end to power supply ground terminal and leave the other end unconnected.) Remote sensing (Paragraph 3-13) may be used simultaneously with remote programming. However, the strapping patterns shown in Figures 3-4, 3-5, and 3-6 employ only local sensing and do not show the load connections.

CAUTION

Turn-off power supply before rearranging strapping pattern at the power supply rear terminal strip. If the current programming terminals are opened while the power supply is on, the output current will exceed its maximum rating and may result in damage to the load. The power supply will not be damaged. The constant voltage programming terminals have a zener diode connected internally across them to limit the programming voltage and thus prevent excessive output voltage.

3-18 CONSTANT VOLTAGE. In the constant voltage mode of operation, either a resistance or voltage source can be used for remote programming. For resistance programming, the programming coefficient (fixed by the programming current) is 200 ohms per Volt (output voltage increases 1 Volt for each 200 ohms in series with programming terminals). The programming current is adjusted to within 1% of 5mA at the factory. If greater programming accuracy is required, change R39 (shunt). The programming resistance should be a stable, low noise, low-temperature (less than 30 ppm per °C) resistor with a power rating at least 10 times its actual dissipation.

3-19 The output voltage of the power supply should be 0 +20mV, -100mV when the programming resistance is zero ohms. This tolerance can be improved by changing R6. For further information on improving this tolerance, refer to Paragraph 5-63.

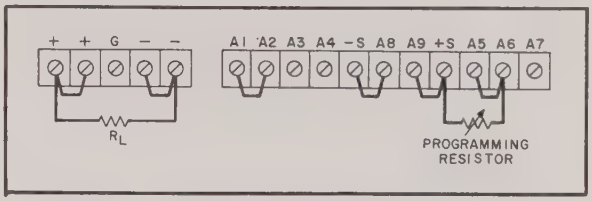


Figure 3-4. Remote Resistance Programming (Constant Voltage)

3-20 If the resistance programming device is controlled by a switch, make-before-break contacts should be used in order to avoid momentary opening of the programming terminals. To connect the remote programming resistance, arrange rear terminal strapping pattern as shown in Figure 3-4. The front-panel VOLTAGE controls are disabled when the strap between A6 and A7 is removed.

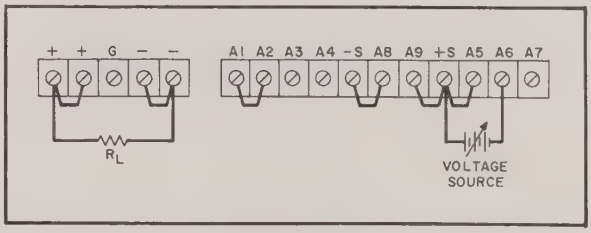


Figure 3-5. Remote Voltage Programming (Constant Voltage)

3-21 If a voltage source is used as the remote programming device, the output voltage of the power supply will vary in a 1 to 1 ratio with the programming voltage. The load on the voltage source will not exceed 25 microamperes. To connect the programming voltage, arrange rear terminal strapping pattern as shown in Figure 3-5.

3-22 CONSTANT CURRENT. In constant current operation, resistance programming is used. The resistance programming coefficient (fixed by the programming current) is 10 ohms per Ampere (output current increases 1 Ampere for each 10 ohms in series with programming terminals). The programming current is adjusted to within approximately 10% of 2mA at the factory. If greater programming accuracy is required, change R41 (shunt). The

programming resistance should be a stable, low noise, low-temperature (less than 30 ppm per °C) resistor with a power rating at least 10 times its actual dissipation.

3-23 The output current of the power supply should be 0 +100mA, -450mA when the programming resistance is zero ohms. This tolerance can be improved by changing R20. For further information on improving this tolerance, refer to Paragraph 5-61.

3-24 If the resistance programming device is controlled by a switch, make-before-break contacts should be used to avoid momentary opening of the programming terminals. To connect the remote programming resistance, arrange rear terminal strapping as shown in Figure 3-6. The front-panel CURRENT controls are disabled when the strap between A1 and A2 is removed.

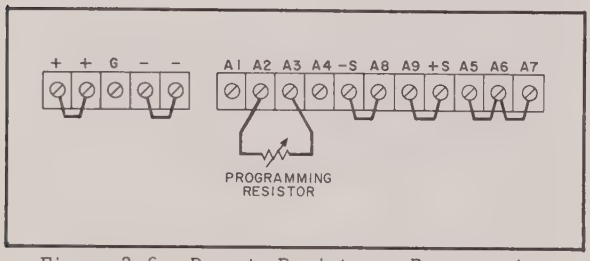


Figure 3-6. Remote Resistance Programming (Constant Current)

3-25 PARALLEL

3-26 Two or more power supplies can be connected in parallel to obtain a total output current greater than that available from one power supply. The total output current is the sum of the output currents of the individual power supplies. Each power supply can be turned-on or off separately. Remote sensing (Paragraph 3-13) and programming (Paragraph 3-16) can be used; however, the strapping patterns shown in Figures 3-7 and 3-8 employ only local sensing and programming.

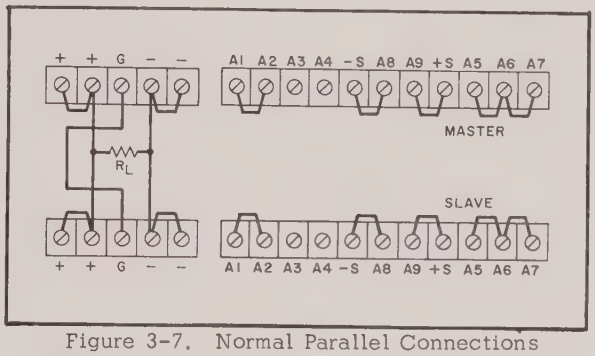


Figure 3-7. Normal Parallel Connections

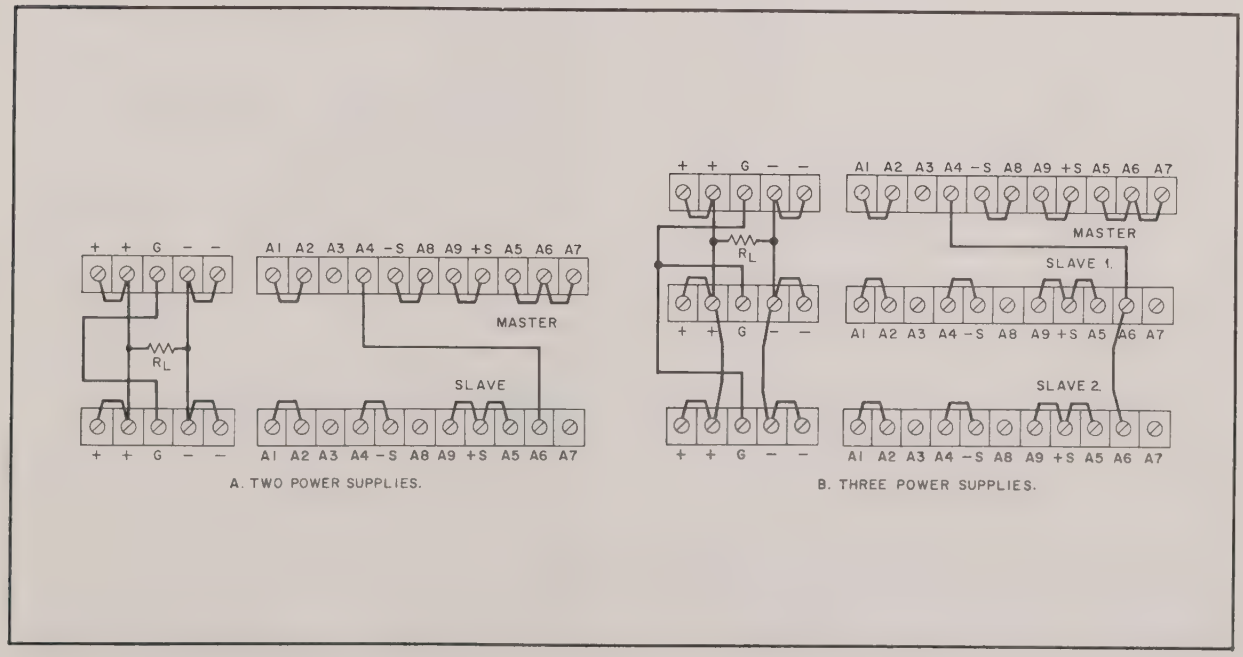


Figure 3-8. Auto-Parallel, Two And Three Units

3-27 NORMAL. The strapping pattern for normal parallel operation of two power supplies is shown in Figure 3-7. The output current controls of each power supply can be separately set. The output voltage controls of one power supply (master) should be set to the desired output voltage; the other power supply (slave) should be set for a slightly larger output voltage. The master will act as a constant voltage source; the slave will act as a constant current source, dropping its output voltage to equal the master's.

3-28 AUTO-PARALLEL. The strapping patterns for auto-parallel operation of two and three power supplies are shown in Figures 3-8A and B, respectively. Auto-parallel operation permits equal current sharing under all load conditions, and allows complete control of output current from one master power supply. The output current of each slave is approximately equal to the master's. Because the output current controls of each slave is operative, they should be set to maximum to avoid having the slave revert to constant current operation; this would occur if the master output current setting exceeded the slave's.

3-29 SERIES

3-30 Two or more power supplies can be connected in series to obtain a total output voltage higher than that available from one power supply. The total output voltage is the sum of the output voltages of the individual power supplies. A single load can be connected across the series-connected power supplies or a separate load can be connected across each power supply. The power supply has a reverse polarity diode connected internally across the output terminals to protect the power supply against reverse polarity voltage if the load is short-circuited or if one power supply is turned off while its series partners are on.

3-31 The output current controls of each power supply are operative and the current limit is equal to the lowest control setting. If any output current controls are set too low with respect to the total output voltage, the series power supplies will automatically crossover to constant current operation and the output voltage will drop. Remote sensing (Paragraph 3-13) and programming (Paragraph 3-16) can be used; however, the strapping patterns shown in Figures 3-9 and 3-10 employ only local sensing and programming.

3-32 NORMAL. The strapping pattern for normal series operation of two power supplies is shown in Figure 3-9. The output voltage controls of each power supply must be adjusted to obtain the total output voltage.

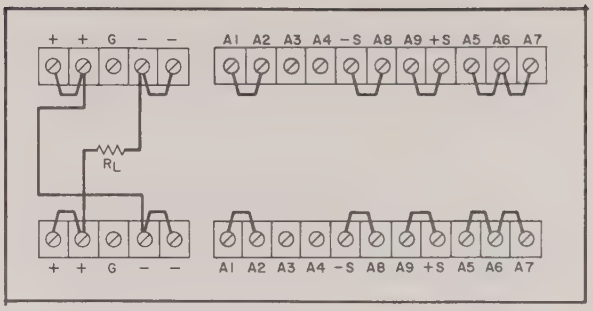


Figure 3-9. Normal Series Connections

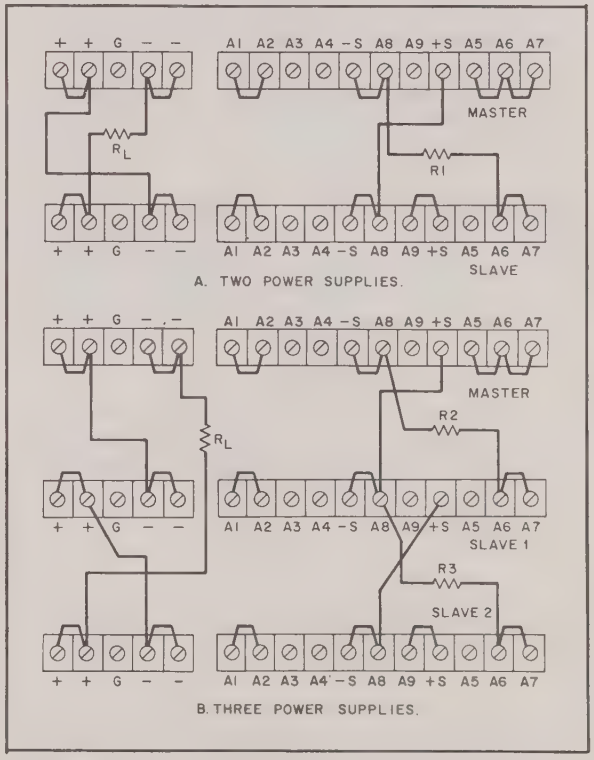


Figure 3-10. Auto-Series, Two and Three Units

3-33 AUTO-SERIES. The strapping patterns for auto-series operation of two and three power supplies are shown in Figures 3-10A and B, respectively. Auto-series operation permits control of the output voltage of several power supplies (slaves) from one master power supply. The master must be the most negative power supply of the series. To obtain positive and negative voltages, the + terminal of the master may be grounded. For a given position of the slave output voltage controls, the total output voltage is determined by the master output voltage controls. The output voltage controls of a slave determines the percentage of the total output voltage that the slave

will contribute. Turn-on and turn-off of the series is controlled by the master. In order to maintain the temperature coefficient and stability specifications of the power supply, the external resistors shown in Figures 3-10A and B, should be stable, low-temperature (less than 30ppm per °C) resistors. The value of these resistors is determined by multiplying the output voltage of the applicable slave by the programming coefficient (200 ohms/ Volt).

3-34 AUTO-TRACKING

3-35 The strapping patterns for auto-tracking operation of two and three power supplies are shown in Figures 3-11A and B, respectively. Automatic tracking operation permits the output voltages of two or more power supplies to be referenced to a common buss; one of the power supplies (master) controls the magnitude of the output voltage of the others (slaves) for a given position of the slave output voltage controls. The master must be the most negative power supply in the group. The output voltage of a slave is a percentage of the master output voltage. The output voltage controls of a slave determines this percentage. Turn-on and turn-off of the power supplies is controlled by the master. Remote sensing (Paragraph 3-13) and programming (Paragraph 3-16) can be used; however, the strapping patterns shown in Figure 3-4 employ only local sensing and programming.

3-36 The value of the external resistors shown in Figure 3-11 is determined by dividing the voltage difference between the master and the applicable slave by the programming current (nominally 5mA; refer to Paragraph 3-18). Finer adjustment of the slave output voltage can be accomplished using the slave output voltage controls. In order to maintain the temperature coefficient and stability specifications of the power supply, the external resistors should be stable, low-noise, low-temperature (less than 30ppm per °C) resistors.

3-37 OPERATING CONSIDERATIONS

3-38 PULSE LOADING

3-39 The power supply will automatically cross over from constant voltage to constant current operation, or the reverse, in response to an increase (over the preset limit) in the output current or voltage, respectively. Although the preset limit may be set higher than the average output current or voltage, high peak currents or voltages (as occur in pulse loading) may exceed the preset limit and cause crossover to occur. To avoid this unwanted crossover, the preset limit must be set for the peak requirement and not the average.

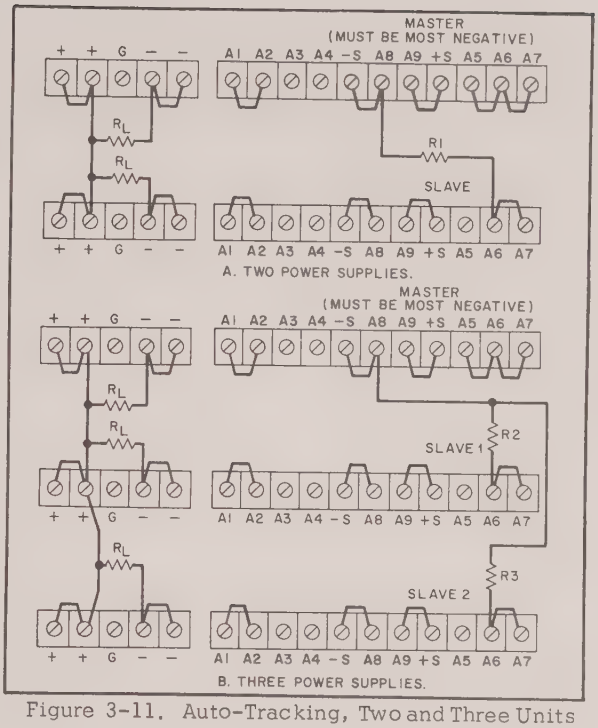


Figure 3-11. Auto-Tracking, Two and Three Units

3-40 OUTPUT CAPACITANCE

3-41 There are capacitors (internal) across the output terminals of the power supply. These capacitors help to supply high-current pulses of short duration during constant voltage operation. Any capacitance added externally will improve the pulse current capability, but will decrease the safety provided by the constant current circuit. A high-current pulse may damage load components before the average output current is large enough to cause the constant current circuit to operate.

3-42 The effects of the output capacitors during constant current operation are as follows:

a. The output impedance of the power supply decreases with increasing frequency.

b. The rise time of the output voltage is increased.

c. A large surge current causing a high power dissipation in the load occurs when the load impedance is reduced rapidly.

3-43 NEGATIVE VOLTAGE LOADING

3-44 A diode is connected across the output terminals. Under normal operating conditions, the diode is reverse biased (anode connected to negative terminal). If a negative voltage is applied to the output terminals (positive voltage applied

to negative terminal), the diode will conduct, shunting current across the output terminals and limiting the voltage to the forward voltage drop of the diode. This diode protects the filter and output electrolytic capacitors.

3-45 NEGATIVE CURRENT LOADING

3-46 Certain types of loads may cause current to flow into the power supply in the direction opposite to the output current. If the reverse current exceeds 0.6 Ampere, preloading will be necessary. For example; if the load delivers 1 Ampere to the power supply with the power supply output voltage at 18Vdc, a resistor equal to 18 ohms (18V/1A) should be connected across the output terminals. Thus, the 18 ohm resistor shunts the reverse current across the power supply. For more information on preloading, refer to Application Note 90, available at no charge from your hp Sales Office.

SECTION IV
PRINCIPLES OF OPERATION

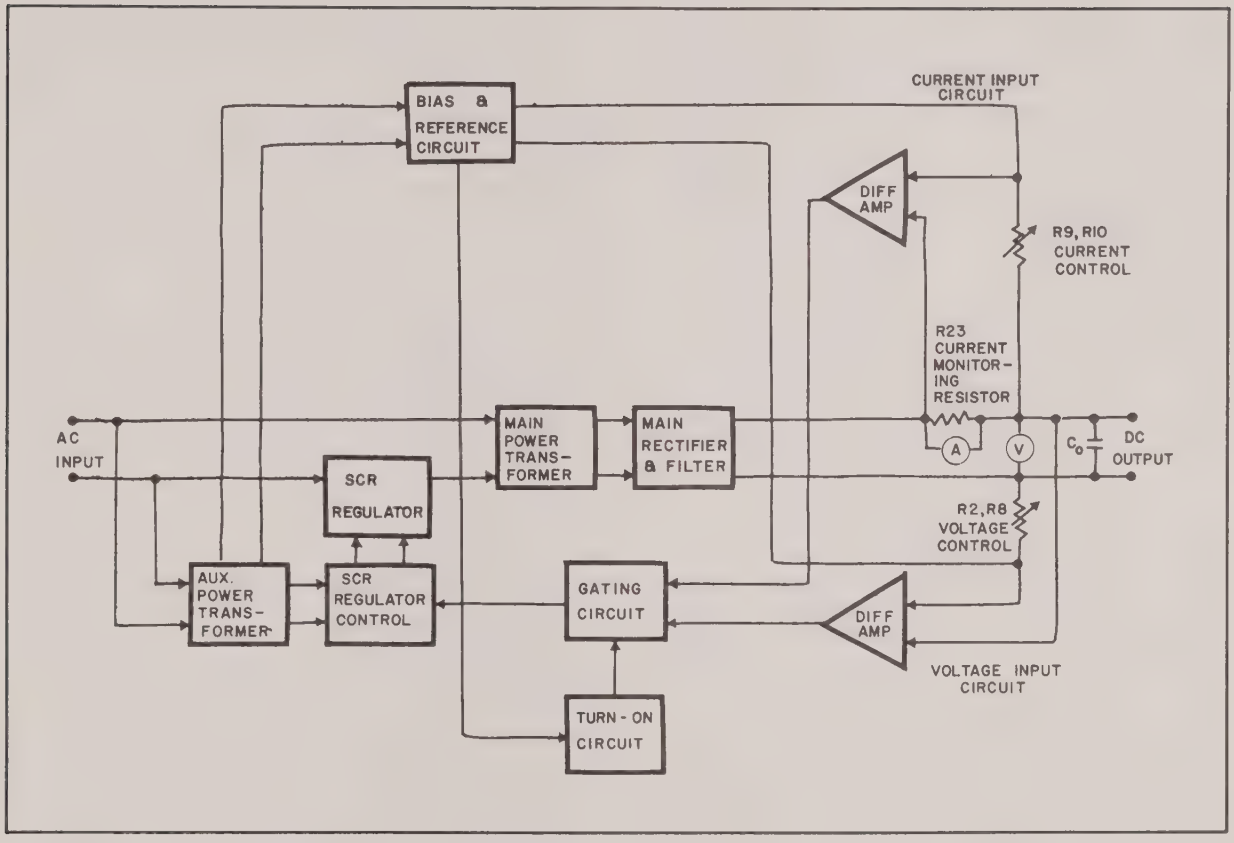


Figure 4-1. Block Diagram

4-1 BLOCK DIAGRAM DESCRIPTION (See Figure 4-1)

4-2 The main power transformer isolates the ac input from the power supply and reduces it to the voltage level required. Rectification and filtering produces a smoothed dc output across the - and + terminals. A large capacitor (C_O) is connected across the - and + terminals for low ac output impedance and to help supply large pulse currents. An SCR regulator controls the ac input to provide good regulation of the dc output. The auxiliary power transformer powers the SCR regulator control circuit and the bias and reference circuit which produces dc bias and reference voltages for the power supply.

4-3 The SCR regulator is controlled by the SCR regulator control circuit which operates in response to signals developed by the voltage or current input circuit. A gating circuit assures that only one input circuit is used at a time.

4-4 The voltage and current input circuits operate in a similar manner. Each circuit has a differential amplifier that amplifies an error voltage that is proportional to the difference between the actual output and the programmed output. The programmed output is determined by the resistance of the programming resistors (voltage and current controls). Each programming resistor has a constant current through it which is maintained by the bias and reference circuit.

4-5 The voltage input circuit differential amplifier detects the error voltage that is proportional to the difference between the voltage across its programming resistors (R2, R8) and the dc output voltage. The error voltage is amplified and passed through the gating circuit to the SCR regulator control which triggers the SCR regulator. The SCR regulator increases or decreases the ac input voltage to the main power transformer as required to maintain a constant load voltage that is equal to the programmed voltage. In constant voltage operation, the gating circuit is biased to inhibit the input from the current input circuit.

4-6 The current input circuit differential amplifier detects the error voltage that is proportional to the difference between the voltage across its programming resistors (R9-R10) and the voltage across current monitoring resistor R23. The voltage across R23 is proportional to the load current. The SCR regulator responds to the amplified error voltage by increasing or decreasing the ac input current to the main power transformers as required to maintain a constant load current. In constant current operation, the gating circuit is biased to inhibit the input from the voltage input circuit.

4-7 To prevent overvoltage and excessive surge current when the power supply is turned-on, the turn-on circuit establishes initial conditions in the gating circuit. The turn-on circuit is activated by the bias and reference circuit when the power supply is turned-off.

4-8 A voltmeter is connected across the - and + terminals to monitor the output voltage. An ammeter is connected across current monitoring resistor R23 to monitor the output current (proportional to voltage across R23).

4-9 CIRCUIT DESCRIPTION (See overall schematic at rear of manual.)

4-10 AC INPUT

4-11 The 115Vac ±10%, 57-63Hz, single phase input is applied through circuit breaker CB1 to transformer T2 and to the series combination of transformer T1 and SCR's CR17 and CR18 which are in parallel opposition. The SCR's are used to regulate the dc output by controlling the average value of the ac input to transformer T1. Capacitors C11 and C12 smooth transients to prevent the SCR's from being triggered by a rapidly changing voltage from anode to cathode. Resistor R21 damps oscillations that may occur due to resonance of C12 and the leakage inductance of T1. The leakage inductance of T1 limits the peak input current. The fan is also energized by the ac input.

4-12 DC OUTPUT

4-13 The output of the secondary of transformer T1 is full-wave rectified by bridge rectifier CR19 through CR22 and filtered by pi-section filter C14 through C17, and L1. Resistor R29 damps the parallel resonance of L1 and C17. The dc output is regulated to a constant value by the SCR's in the ac input line. Capacitor C17 is the output capacitor. Diode CR23 is connected across the filtered dc output to protect the power supply from reverse voltage applied to the output terminals. Resistor R23 is the current monitoring resistor; the full load current flows through it. Resistors R25 and R27 are used to calibrate the voltmeter and ammeter, respectively.

4-14 VOLTAGE INPUT

4-15 The voltage input circuit is basically a differential amplifier (Q1-Q2) that detects any voltage difference between the programmed output voltage and the actual output voltage. The differential amplifier output voltage varies in proportion to the power supply output voltage variation.

4-16 Voltage divider R6-R47 maintains a slightly negative base bias to ensure that the output voltage can be programmed to zero. The output of Q2 is emitter-coupled (resistor R4) to Q1.

4-17 There are three inputs to the base of Q1; one determined by the programmed voltage (voltage controls R2-R8), the second determined by the collector voltage of Q1 (negative feedback), and the third is from the positive side of the main rectifier. The collector current of Q1 is determined by the difference between its base and emitter inputs. This difference is an error voltage that is proportional to the difference between the programmed output voltage and the acutal output voltage. The negative feedback from collector to base (C4, and R17-R18 in parallel) improves the stability of the voltage-regulating feedback loop.

4-18 The input from the positive side of the main rectifier (C1 and R1) improves loop stability by making the differential amplifier insensitive to output voltage variations of four Hz or greater. Below four Hz this input is negligible. This input is necessary because the phase shift of the pi-section output filter begins to become excessive over four Hz. Resistors R1 and R5 are arranged so that the four Hz input is isolated from the negative feedback input; and so that necessary impedance levels are obtained looking out from the base of Q1. The collector output of Q1 is coupled to the gating circuit.

4-19 CLAMPING. In order to protect the differential amplifier, the base of Q1 is clamped with respect to -S by diodes CR1 and CR2 to prevent excessive base voltage in either direction. Diode CR1 clamps the base to approximately -0.7Vdc; CR2 and the base-emitter junction of Q1 clamp the base to approximately +1.4Vdc. Zener diodes VR1 and VR5 clamp the programming terminals to prevent an excessive error signal that would cause excessive output voltage. This would occur, for example, if the programming terminals were opened accidentally. To prevent overshoot when the power supply switches from constant current to constant voltage, diodes CR9 and CR10 clamp the collector of Q1. Resistor R30 provides a small bleed current for CR10.

4-20 CURRENT INPUT

4-21 The current input circuit is basically a differential amplifier (Q8-Q9) that detects any current difference between the programmed output current (proportional to voltage across current controls) and the actual output current (proportional to voltage across current monitoring resistor R23). The differential amplifier output voltage varies in proportion to the output current variation.

4-22 The input to the differential amplifier (across bases of Q8-Q9) is the voltage difference across current controls R9-R10 and current monitoring resistor R23. Because the programming current is constant in constant current operation, the voltage input to the differential amplifier varies as the load current through R23 (error voltage). Capacitors C6 and C24 and resistor R22 provide gain roll-off at high frequencies. Diode CR26 clamps the voltage (0.7Vdc) across the emitter-base junction of Q9 and R20. This clamping action prevents excessive reverse base voltage in Q9 when very large load current is drawn (output terminals shorted). To prevent overshoot when the power supply switches from constant voltage to constant current operation, diodes CR10 and CR12 clamp the collector of Q8.

4-23 Resistor R13 is the collector load for Q8. The collector output of Q8 is coupled to the gating circuit. Voltage divider R20-R46 biases the base of Q9 and maintains a slightly negative base bias to ensure that the output current can be programmed to zero. Resistor R44 provides positive feedback to improve load regulation during constant current operation.

4-24 GATING CIRCUIT

4-25 Transistor Q4 draws current from the SCR control circuit (capacitor C25). The magnitude of this current is determined by either the voltage or current input circuit. For constant voltage operation, diode CR7 is forward biased to permit the voltage input circuit to drive Q4; diode CR8 is reverse biased to inhibit the input from the current input circuit. For constant current operation, the reverse occurs.

4-26 To prevent transients in the dc output when the power supply is turned-on, the turn-on of Q4 is delayed by capacitor C2 which charges through R12, R15 and CR5. When C2 charges sufficiently to reverse bias CR5, all the current through R15 flows to the base of Q4 to turn it on. This base current is controlled by the voltage or current input circuits via CR7 or CR8, respectively. For example, during constant voltage operation the collector voltage of Q1 (voltage input) forward biases CR17 (CR8 reverse biased by Q8), the current through CR7 will vary as Q1 collector voltage varies and thus vary Q4 base current; therefore, the collector current of Q4 is controlled by the voltage input. In a similar manner, the current input circuit controls the collector current of Q4 during constant current operation.

4-27 TURN-ON CIRCUIT

4-28 Transistor Q3 provides a path for rapidly discharging C2 (in gating circuit) when the power supply is turned-off. This assures that C2 is discharged if the power supply is turned-on shortly after turn-off. The purpose of having C2 discharged each time the power supply is turned-on is to maintain the same time delay in the turn-on of the gating circuit (refer to Paragraph 4-26).

4-29 SCR REGULATOR CONTROL (See waveshapes on schematic at rear of manual)

4-30 GENERAL. The SCR regulator control is basically a blocking oscillator (Q7 and T3) that applies pulses to the SCR regulator in response to error signals detected by the voltage or current input circuit. When transistor Q7 conducts, the pulse developed in winding 1-2 of transformer T3 is coupled to the base of Q7 (positive feedback) and to the SCR regulator (CR17 and CR18). Capacitor C27 charges in opposition to the feedback voltage and cuts off Q7. The charge time of C27 determines the pulse duration in the collector of Q7 (approximately 20 microseconds). The 35Vdc bias supplies current through R52, CR46, and CR44 to discharge C27 after Q7 stops conducting.

4-31 GATE INPUT. Throughout the operation of the blocking oscillator, capacitor C25 supplies most of the collector current for Q4 in the gating circuit (refer to Paragraph 4-25). The amount of current pulled from C25 by Q4 is determined by the input (from the voltage or current input circuit)

to the gating circuit. As a result of this current flow from C25, the voltage across C25 increases negatively with respect to the 6.0Vdc bias and has a waveshape that approximates a linear ramp. Thus, the slope of this ramp is determined by the voltage or current input circuit. Due to the time delay in the feedback loop, the slope of the ramp is constant for a half cycle of the ac input. The voltage on C25 is the emitter bias (forward bias when negative) for Q7 and therefore helps determine the point at which Q7 conducts.

4-32 AC INPUT. The ac input to transformer T2 is stepped-down and full-wave rectified by bridge rectifier CR39 through CR43. The output of the bridge rectifier is a negative-going pulsating dc (120Hz). Voltage divider R50-R51 supplies a portion of this pulsating dc through C27 to the base of Q7; thus, the base is reverse biased.

4-33 FIRING. A point is reached during each cycle of the 120Hz pulsating dc (each half cycle of the 60Hz ac input) when the reverse bias on the base and the forward bias (capacitor C25) on the emitter of Q7 are equal, and therefore Q7 has zero bias. As the ramp voltage across C25 goes more negative than the base voltage, the base-emitter junction of Q7 begins to become forward biased. When the emitter is more negative than the base by approximately 0.5 volts, Q7 conducts. The firing point of Q7 is therefore determined by both the dc output error and the line voltage change. Because Q7 saturates when it conducts, the collector voltage approximates a rectangular wave with a negative going pulse width of approximately 20 microseconds (determined by C27 and R51). The conduction of Q7 charges C25 in the positive direction (clamped by CR49). When Q7 stops conducting, the ramp across C25 begins again. However, Q7 is held cut-off by the charge on C27.

4-34 INITIAL CONDITIONS. At the beginning of each cycle of the 120Hz pulsating dc, certain initial conditions must be established on capacitors C25 and C27. When the negative-going pulsating dc is at the end of its cycle (C27 negatively charged earlier in the cycle by the feedback voltage), CR44 and CR45 become forward biased and current flows from the 35Vdc bias through R52, CR46, and CR44 to discharge C27 to approximately zero Volts and through R52, CR46, and CR45 to charge C25 to approximately 0.7 Volts (clamped by CR49). This discharge and charge occurs rapidly, so that it is completed before the next cycle begins and Q7 can conduct again. Diode CR47 provides another path for the current through CR44 so that the voltage to which C27 discharges remains predictable. As the negative-going pulsating dc increases in the next cycle, CR44 and CR45 become reverse biased.

4-35 BRIDGE RECTIFIER. At the zero cross-over region of the voltage waveform on secondary winding 3-4 of transformer T2, the voltage is insufficient to forward bias the rectifiers in the bridge. In order to maintain definition between the end of one cycle of the rectified output and the beginning of the next cycle, diode CR41 provides approximately 0.7 Volts at the rectified output. The current for CR41 is supplied through CR46. As the voltage across the secondary winding moves away from the zero cross-over region, CR41 becomes reverse biased.

4-36 TRANSIENTS, DECOUPLING AND PROTECTION. Transients in the pulsating dc are reduced by R56 and C28. The base of Q7 is decoupled by C3. The voltage spike in the collector of Q7, induced by secondary winding 1-2 of transformer T3 when Q7 cuts-off, is clamped by CR48. The collector is decoupled by R53 and C26. To protect the power supply and load, thermostat TS1 opens the collector circuit of Q7 when the temperature of the SCR heat sinks exceeds 80°C.

4-37 SCR REGULATOR

4-38 The SCR regulator (CR17 and CR18) controls the ac input voltage and current to main power transformer T1 in response to the voltage and current error signals. In constant voltage operation, the ac input voltage to T1 is adjusted so that the output voltage remains constant with changing loads. In constant current operation, the ac input current to T1 is adjusted so that the output current remains constant with changing loads and the output voltage is allowed to vary.

4-39 GATING. Each half cycle of the ac input, either CR17 or CR18 is forward biased. The pulse induced in secondary windings 5-6 and 7-8 of T3 by the SCR control, turns on the SCR that is forward biased when the pulse occurs. The other SCR is not affected by the gate pulse because it is reverse biased. A gate pulse occurs each half cycle of the ac input, unless the output is open. The timing of the gate pulse with respect to the ac input is determined by the error in the dc output via the loop action.

4-40 AC INPUT CONTROL. When an SCR is gated on, it conducts until its anode-to-cathode voltage goes to approximately zero. Thus, the earlier an SCR is gated on, the greater the portion of the ac input that will be applied to T1. Because of the leakage inductance of T1, the conduction of an SCR may extend into the next half cycle. The conduction period may be shortened at high output by the voltage across capacitor C13 through C16

being reflected back into the primary. By controlling the ac input to T1 each half cycle, the average value of the voltage or current at the output of bridge rectifier CR19 through CR21 is adjusted so that dc output voltage or current is maintained constant.

4-41 PROTECTION. Diodes CR50 and CR51 prevent anode induced reverse gate currents from being fed back to the control circuit. Resistors R54 and R55 limit current in the SCR gates.

4-42 BIAS AND REFERENCE CIRCUIT

4-43 The bias and reference circuit supplies three voltages (+35, +6.0, and -19.5Vdc) for internal power supply operation, and maintains the programming currents constant. The +35Vdc is not regulated. The -19.5Vdc, +6.0Vdc, and the programming currents are regulated.

4-44 +35 AND +6.0VDC. The output of secondary winding 5-6 of transformer T2 is full-wave rectified by CR30 and CR31. Capacitors C20 and C21 each charge to the peak rectified voltage (voltage doubling). The +6.0Vdc (with respect to -S) is maintained by diodes CR6 and CR14 and by zener diode VR4. The +35Vdc includes the +6.0Vdc and the negative voltage across C20 provide the unregulated input to the -19.5Vdc regulator.

4-45 -19.5VDC. For the -19.5Vdc, transistor Q10 is the error detector/amplifier. Zener diode VR3 and diode CR27 provide a reference voltage at the emitter of Q10. Voltage divider R35-R36 supplies an error voltage to the base of Q10 which amplifies and applies it to the base of series regulator Q11. The base drive of Q11 adjusts the voltage across Q11 as required to compensate for the error in the -19.5Vdc. Resistor R37 sets the optimum current through temperature-compensated zener diode VR3. Resistor R45 improves the line regulation. Resistor R56 reduces power dissipation in Q11. Capacitor C22 stabilizes the loop.

4-46 PROGRAMMING CURRENTS. Each programming current is held constant in a similar manner. The voltage across emitter resistors R38 and R40 is held constant by VR3, CR27, and the base-emitter drop of each transistor. Thus, the emitter current in each transistor is constant and therefore the collector currents are nearly constant. The collector currents of Q5 and Q6 are the constant voltage and constant current programming currents, respectively. Resistors R39 and R41 are used for trimming. Resistors R42 and R43 are collector loads. Diode CR28 clamps the collector of Q5 to protect against excessive positive voltage (breakdown) which might occur if the voltage controls are reduced to zero rapidly (positive dc output voltage would appear at collector).

SECTION V
MAINTENANCE

5-1 GENERAL

5-2 Table 5-1 lists the type of test equipment, its required characteristics, its use, and a recommended model for performing the instructions given in this section. Upon receipt of the power supply, the performance check (Paragraph 5-7) should be made. This check is suitable for incoming inspection. Additional specification checks are given in Paragraphs 5-24 through 5-35. If a fault is detected in the power supply while making the performance check or during normal operation, proceed to the troubleshooting procedures (Paragraph 5-39). After troubleshooting and repair (Paragraph 5-46), perform any necessary adjustments and calibrations (Paragraph 5-48). Before returning the power supply to normal operation, repeat the performance check to ensure that the fault has been properly corrected and that no other faults exist. Before doing any maintenance checks, turn-on power supply, allow a half-hour warm-up, and read the measurement techniques (Paragraph 5-3).

Table 5-1. Test Equipment

Type	Required Characteristics	Use	Recommended Model
Differential Voltmeter	Sensitivity: 1mV full scale (min.) Input impedance: 10 megohms	Measure regulation and dc voltages; calibrate meters	hp 741A (See Note 1)
AC Voltmeter	Accuracy: 2% Sensitivity: 1mV full scale (min.)	Measure ac voltages and ripple	hp 403B
Variable Voltage Transformer	Range: 90-130 Volts Equipped with voltmeter accurate within 1 Volt	Vary and measure ac input voltage	--
Oscilloscope	Sensitivity: 5mV/cm (min.) Differential input	Measure ripple and transient response	hp 130C
Battery	18Vdc	Measure transient response	--
Switch	45 Ampere capacity	Transient response; Constant current load regulation	--
Resistor	1.6 ohm, ±5% 1 kW	Load resistor	Rex Rheostat (See Note 2)
Resistor	1 milliohm, 45 Amperes 4 terminals	Current monitoring	Any 50mV, 50 Ampere meter shunt

Table 5-1. Test Equipment (Continued)

Type	Required Characteristics	Use	Recommended Model
Resistor	1,000 ohms, ±1%, 2W non-inductive	Measure impedance	--
Resistor	100 ohms, ±5% 10W	Measure impedance	--
Capacitor	500μfd, 50 VdcW	Measure impedance	--
Oscillator	Range: 1Hz to 100kHz Accuracy: 2% Output: 10 Vrms	Measure impedance	hp 202C
Controlled-temperature Oven	Range: 0-50°C	Measure temperature stability	--
Resistance Box	Range: 0-3,600 ohms Accuracy: 0.1% plus 1 ohm Make-before-break contacts	Measure programming coefficients	hp 6931A

NOTE #1

A satisfactory substitute for a differential voltmeter is to arrange a reference voltage source and null detector as shown in Figure 5-1. The reference voltage source is adjusted so that the voltage difference between the supply being measured and the reference voltage will have the required resolution for the measurement being made. The voltage difference will be a function of the null detector that is used. For measurements at the base of transistor Q4, a null detector with input impedance of 10 megohms or greater is required. Otherwise, satisfactory null detectors are: hp 405AR digital voltmeter, hp 412A dc voltmeter, hp 419A null detector, a dc coupled oscilloscope utilizing differential input, or a 50mV meter movement with a 100 division scale. A 2mV change in voltage will result in a meter deflection of four divisions.

CAUTION

Care must be exercised when using an electronic null detector in which one input terminal is grounded to avoid ground loops and circulating currents.

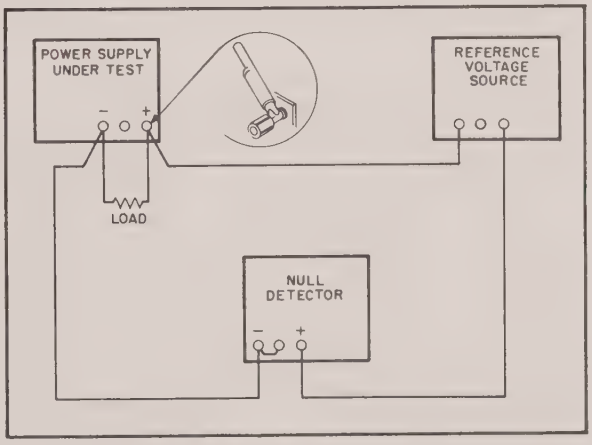


Figure 5-1. Differential Voltmeter Substitute, Test Setup

NOTE #2

To obtain 1.6 ohms, connect rheostat across output terminals, turn front-panel CURRENT controls fully clockwise (maximum), adjust front-panel VOLTAGE controls for 40Vdc and adjust rheostat until output current is 25 Amperes. Use fan to cool rheostat.

5-3 MEASUREMENT TECHNIQUES

5-4 A measurement made across the load includes the effect of the impedance of the leads connecting the load; these leads can have an impedance several orders of magnitude greater than the output impedance of the power supply. When measuring the output voltage of the power supply, use the -S and +S terminals.

5-5 For output current measurements, the current monitoring resistor should be a four-terminal resistor. The four terminals are connected as shown in Figure 5-2.

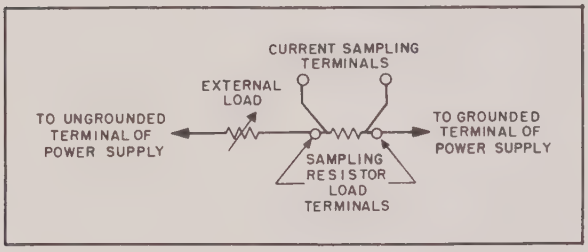

CURRENT SAMPLING TERMINALS
EXTERNAL LOAD
TO UNGROUNDED TERMINAL OF POWER SUPPLY
TO GROUNDED TERMINAL OF POWER SUPPLY
SAMPLING RESISTOR LOAD TERMINALS

Figure 5-2. Output Current Measurement Technique

5-6 When using an oscilloscope, ground one terminal of the power supply and ground the case at the same ground point. Make certain that the case is not also grounded by some other means (power line). Connect both oscilloscope input leads to the power supply ground terminal and check that the oscilloscope is not exhibiting a ripple or transient due to ground loops, pick-up, or other means.

5-7 PERFORMANCE CHECK

5-8 GENERAL

5-9 The performance check is made using a 115 Volt, 60Hz, single-phase input power source. The performance check is normally made at a constant ambient room temperature. The temperature range specification can be verified by doing the performance check at a controlled temperature of 0°C and at a controlled temperature of 50°C. If the correct result is not obtained for a particular check, do not adjust any controls; proceed to troubleshooting (Paragraph 5-39).

5-10 RATED OUTPUT AND METER ACCURACY

5-11 CONSTANT VOLTAGE. Proceed as follows:

a. Connect the 1.6 ohm load resistor across the output terminals and the differential voltmeter across the -S and +S terminals.

b. Turn front-panel CURRENT controls fully clockwise (maximum).

c. Turn front-panel VOLTAGE controls until front-panel voltmeter indicates 40.0Vdc.

d. The differential voltmeter should indicate 40 ±0.80Vdc.

5-12 CONSTANT CURRENT. Proceed as follows:

a. Connect test setup shown in Figure 5-3.

b. Turn front-panel VOLTAGE controls fully clockwise (maximum).

c. Turn front-panel CURRENT controls until front-panel ammeter indicates 25.0 Amperes.

d. The differential voltmeter should indicate 0.5±.01V.

5-13 LINE REGULATION

5-14 CONSTANT VOLTAGE. Proceed as follows:

a. Connect the 1.6 ohm load resistor across the output terminals and the differential voltmeter across the -S and +S terminals.

b. Turn front-panel CURRENT controls fully clockwise (maximum).

c. Connect the variable voltage transformer between the input power source and the power supply power input. Adjust the variable voltage transformer to 105Vac.

d. Turn front-panel VOLTAGE controls until the differential voltmeter indicates 40.0Vdc.

e. Adjust the variable voltage transformer to 125Vac.

f. Differential voltmeter indication should change by less than 18mVdc.

5-15 CONSTANT CURRENT. Proceed as follows:

a. Connect test setup shown in Figure 5-3.

b. Turn front-panel VOLTAGE controls fully clockwise (maximum).

c. Connect the variable voltage transformer between the input power source and the power supply power input. Adjust the variable voltage transformer to 105Vac.

d. Turn front-panel CURRENT controls until front-panel ammeter indicates 25 Amperes.

e. Record voltage indicated on differential voltmeter.

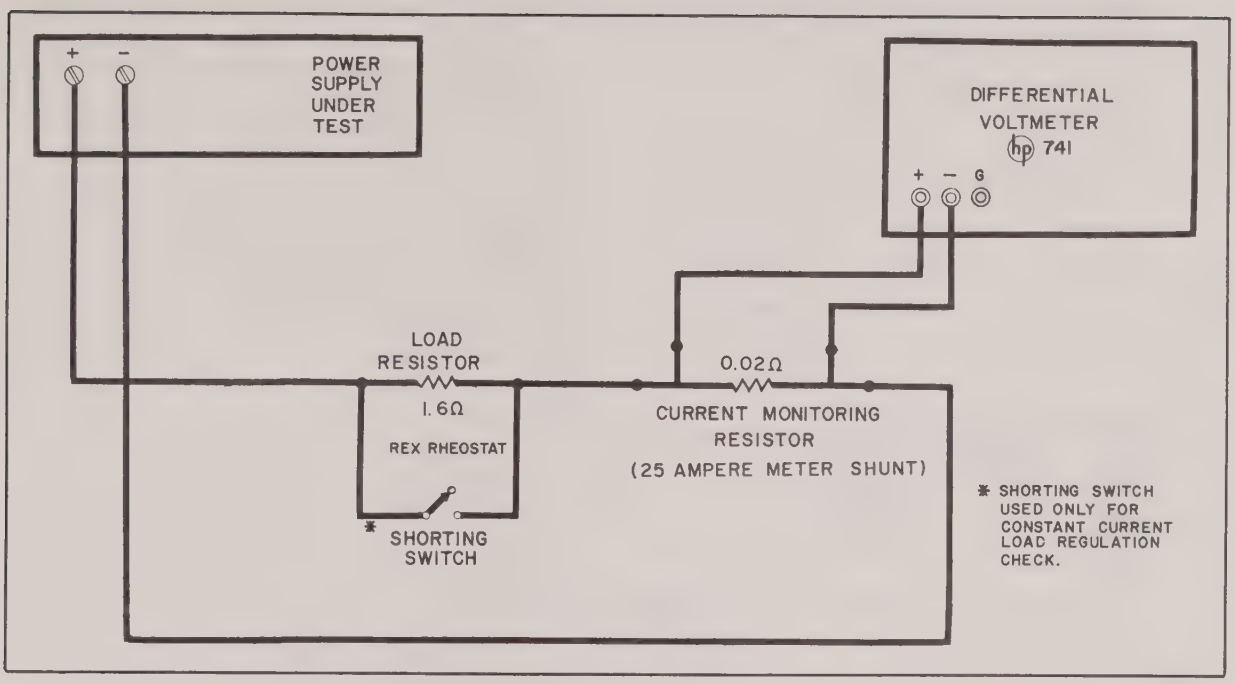


Figure 5-3. Constant Current, Test Setup

f. Adjust the variable voltage transformer to 125Vac.

g. Differential voltmeter indication should change by less than 4.0 mVdc.

5-16 LOAD REGULATION

5-17 CONSTANT VOLTAGE. Proceed as follows:

a. Connect the 1.6 ohm load resistor across the output terminals and the differential voltmeter across the -S and +S terminals.

b. Turn front-panel CURRENT controls fully clockwise (maximum).

c. Turn the front-panel VOLTAGE controls until front-panel ammeter indicates 25 Amperes.

d. Record voltage indicated on differential voltmeter.

e. Disconnect load resistor.

f. Differential voltmeter indication should change by less than 40 mVdc.

5-18 CONSTANT CURRENT. Proceed as follows:

a. Connect test setup shown in Figure 5-3.

b. Turn front-panel VOLTAGE controls fully clockwise (maximum).

c. Turn front-panel CURRENT controls until front-panel ammeter indicates 25 Amperes.

d. Record voltage indicated on differential voltmeter.

e. Close the shorting switch.

f. Differential voltmeter indication should change by less than 4.0 mVdc.

5-19 RIPPLE AND NOISE

5-20 Proceed as follows:

a. Connect the 1.6 ohm load resistor across the output terminals and the ac voltmeter across the -S and +S terminals.

b. Turn front-panel CURRENT controls fully clockwise (maximum).

c. Connect the variable voltage transformer between the input power source and the power supply power input. Adjust the variable voltage transformer to 125Vac.

d. Turn front-panel VOLTAGE controls until front-panel ammeter indicates 25 Amperes.

e. The ac voltmeter should indicate less than 40 mVrms.

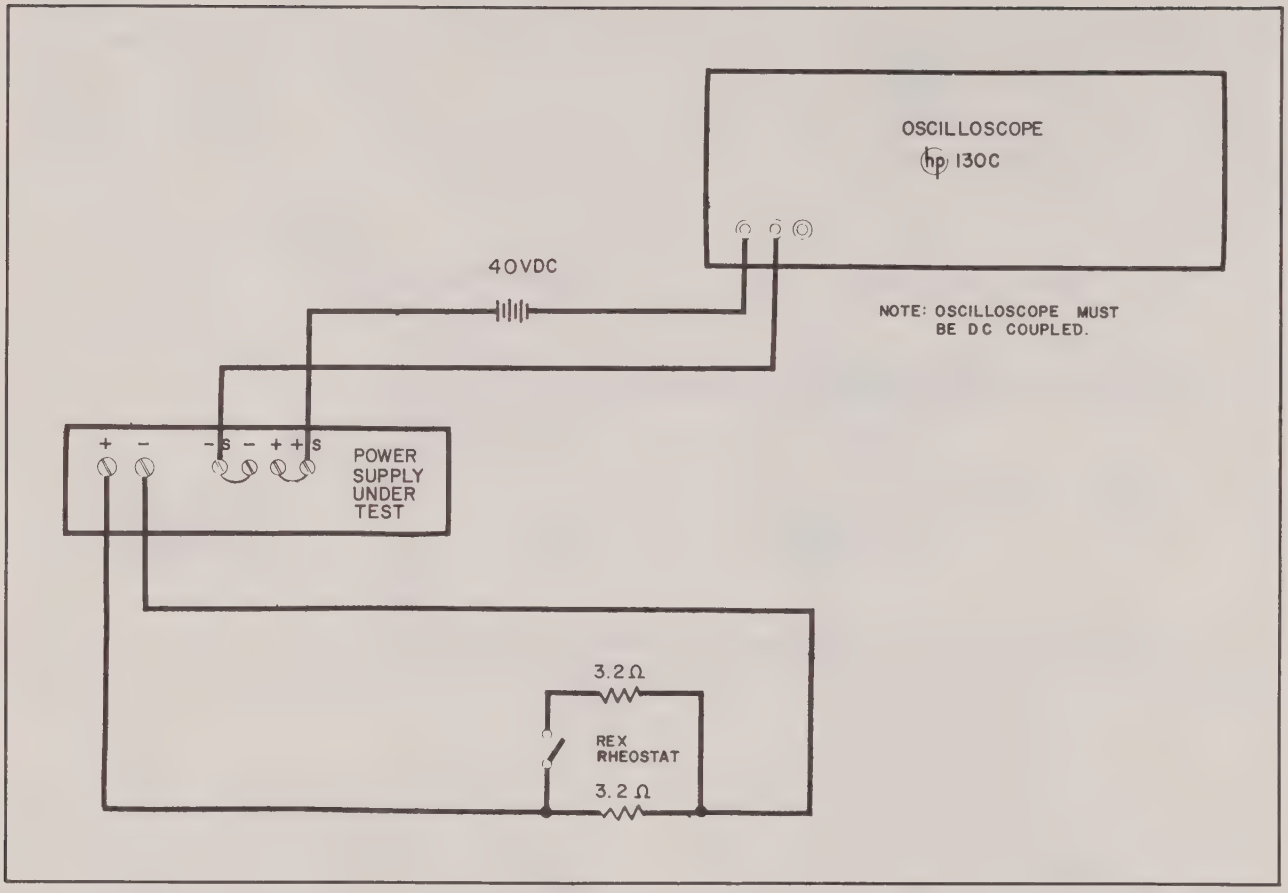


Figure 5-4. Transient Recovery Time, Test Setup

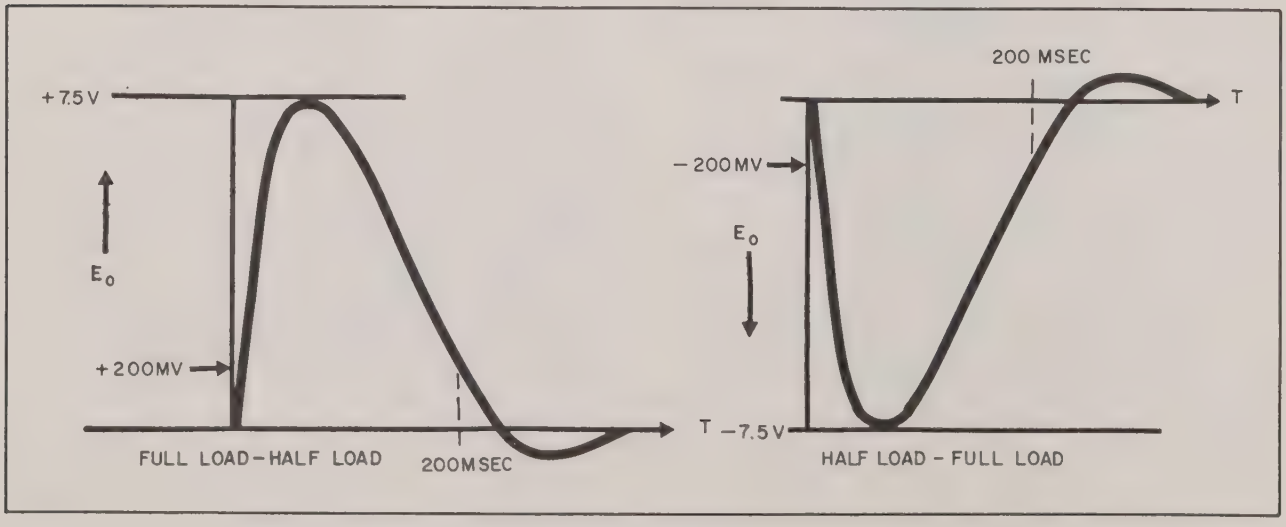


Figure 5-5. Transient Recovery Time, Waveform

5-21 TRANSIENT RECOVERY TIME

5-22 Proceed as follows:

a. Connect test setup shown in Figure 5-4.

b. Turn front-panel CURRENT controls fully clockwise (maximum).

c. Turn front-panel VOLTAGE controls until front-panel ammeter indicates 25 Amperes.

d. Open and close the switch several times and observe the oscilloscope display.

e. Oscilloscope display should be as shown in Figure 5-5.

5-23 ADDITIONAL SPECIFICATION CHECK

5-24 TEMPERATURE COEFFICIENT

5-25 CONSTANT VOLTAGE. Proceed as follows:

a. Connect the 1.6 ohm load resistor across the output terminals and the differential voltmeter across the -S and +S terminals.

b. Turn front-panel CURRENT controls fully clockwise (maximum).

c. Turn front-panel VOLTAGE controls until the differential voltmeter indicates 40Vdc.

d. Insert the power supply into the controlled-temperature oven (differential voltmeter and load remain outside oven). Set the temperature to 30°C and allow a half-hour warm-up.

e. Record the differential voltmeter indication.

f. Raise the temperature to 40°C and allow a half-hour warm-up.

g. Differential voltmeter indication should change by less than 125 mVdc from indication recorded in step e.

5-26 CONSTANT CURRENT. Proceed as follows:

a. Connect test setup shown in Figure 5-3.

b. Turn front-panel VOLTAGE controls fully clockwise (maximum).

c. Turn front-panel CURRENT controls until the differential voltmeter indicates 0.5 Volts.

d. Insert the power supply into the controlled-temperature oven (differential voltmeter and load remain outside oven). Set the temperature to 30°C and allow a half-hour warm-up.

e. Record the differential voltmeter indication.

f. Raise the temperature to 40°C and allow a half-hour warm-up.

g. Differential voltmeter indication should change by less than 15 mVdc from indication recorded in step e.

5-27 OUTPUT STABILITY

5-28 CONSTANT VOLTAGE. Proceed as follows:

a. Connect the 1.6 ohm load resistor across the output terminals and the differential voltmeter across the -S and +S terminals.

b. Turn front-panel CURRENT controls fully clockwise (maximum).

c. Turn front-panel VOLTAGE controls until the differential voltmeter indicates 40Vdc.

d. Allow a half-hour warm-up and then record the differential voltmeter indication.

e. After eight hours, the differential voltmeter indication should change by less than 60 mVdc from indication recorded in step d.

5-29 CONSTANT CURRENT. Proceed as follows:

a. Connect test setup shown in Figure 5-3.

b. Turn front-panel VOLTAGE controls fully clockwise (maximum).

c. Turn front-panel CURRENT controls until the differential voltmeter indicates 0.5 Volts.

d. Allow a half-hour warm-up and then record the differential voltmeter indication.

e. After eight hours, the differential voltmeter indication should change by less than 5 mVdc.

5-30 OUTPUT IMPEDANCE

5-31 Proceed as follows:

a. Connect test setup shown in Figure 5-6.

b. Turn front-panel CURRENT controls fully clockwise (maximum).

c. Turn front-panel VOLTAGE controls until front-panel voltmeter indicates 9Vdc.

d. Adjust the oscillator for a 10 Vrms (E_{in}), 0.5Hz output.

e. Calculate and record the output impedance using the following formula:

$$Z_{out} = E_o R/(E_{in} - E_o)$$

R = 1,000 ohms; E_o measured across power supply -S and +S terminals using ac voltmeter; E_{in} measured across oscillator output terminals using the ac voltmeter.

f. Using the formula given in step e, calculate and record the output impedance for oscillator frequencies of 100Hz, 1kHz, and 100kHz.

g. The output impedance calculated and recorded in steps e and f should fall into the following ranges:

(1) dc to 0.5Hz; less than 0.01 ohm
(2) 0.5Hz to 100Hz; less than 0.5 ohm
(3) 100Hz to 1kHz; less than 0.1 ohm
(4) 1kHz to 100kHz; less than 0.6 ohm

5-32 OUTPUT INDUCTANCE

5-33 Proceed as follows:

a. Repeat steps a through c of Paragraph 5-31.

b. Adjust the oscillator for a 10 Vrms (E_{in}), 10kHz output.

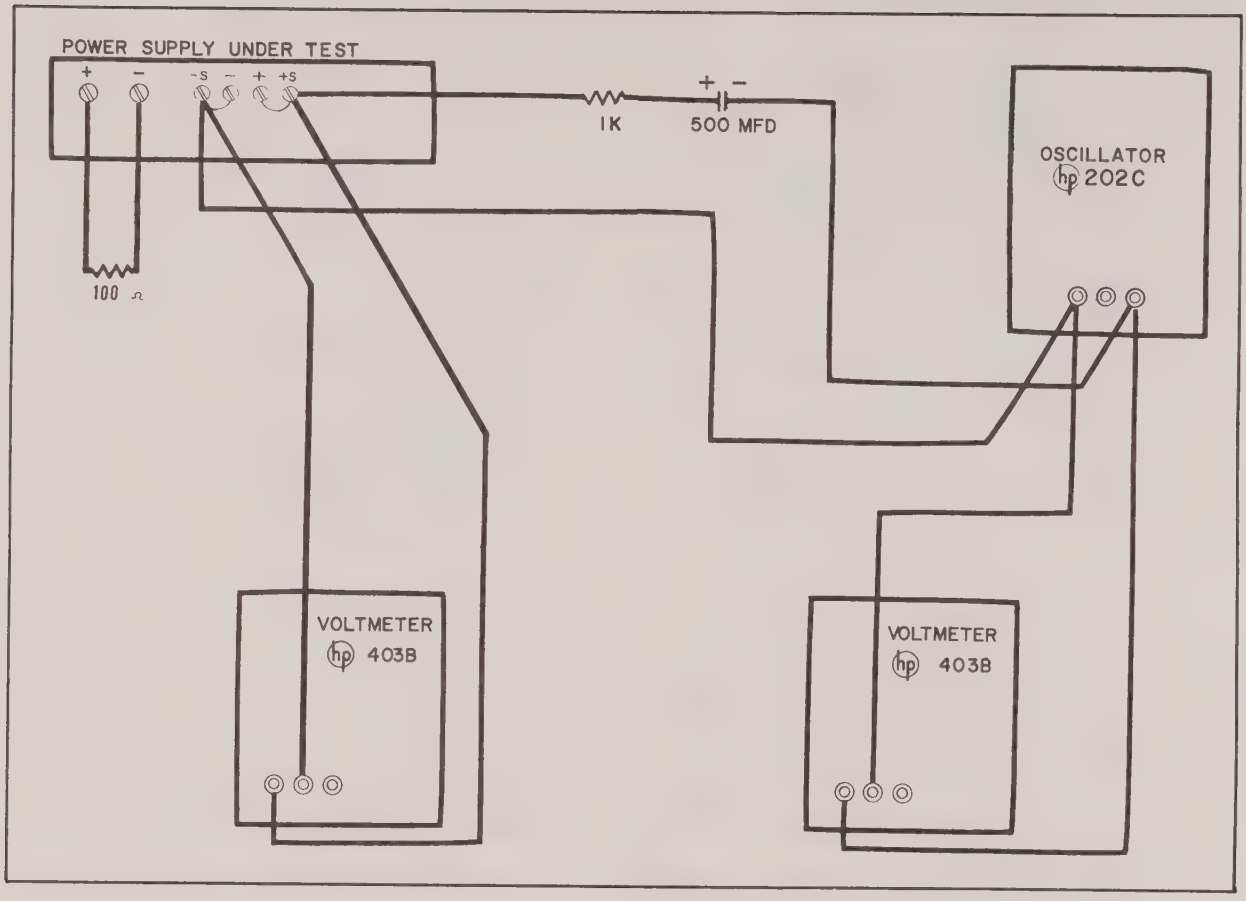


Figure 5-6. Output Impedance, Test Setup

c. Calculate and record the output inductance using the following formula:

$$L = X_1/2\pi f$$

X_1 is the output impedance (Z_{out}) calculated in steps e and f of Paragraph 5-31; f is the frequency of the oscillator (determines which Z_{out} is used).

NOTE

The equation assumes that $X_1 \gg R_{out}$ and therefore $X_1 = Z_{out}$.

d. Using the formula given in step c, calculate and record the output inductance for oscillator frequencies of 50kHz and 100kHz at 10 Vrms.

e. The output inductance calculated in steps c and d should not exceed 1.0 microhenry.

5-34 COVER REMOVAL

5-35 The top and bottom covers are removed by removing both sets of six attaching screws.

5-36 TROUBLESHOOTING

5-37 GENERAL

5-38 If a fault in the power supply is suspected, remove the covers (Paragraph 5-35) and visually inspect for broken connections, burned components, etc. If the fault is not detected visually, proceed to trouble analysis (Paragraph 5-39). If the fault is detected visually or via trouble analysis, correct it and then do the performance check (Paragraph 5-7). If a part is replaced, refer to repair and replacement (Paragraph 5-47) and to adjustments and calibrations (Paragraph 5-48).

Table 5-2. Normal Voltage

From (+)	To (-)	Voltage	Typical Peak-to-Peak Values
-S	51	19.5 ±1.0Vdc	0.05V
33	27	34.1 ±1.7Vdc	1.0 V
33	-S	6.0 ±0.3Vdc	0.1 V
40	33	33.0 ±1.7Vdc	0.6 V
24	51	10.3 ±0.6Vdc	---
22	51	9.7 ±0.5Vdc	---
21	51	9.7 ±0.5Vdc	---
23	22	7.1 ±0.7Vdc	---
20	21	3.1 ±0.3Vdc	---
39	38	0.81 ±0.1Vdc	---
51	27	6.6 ±2.0Vdc	1.0 V
33	12	6.0 ±0.6Vdc	---
26	27	0.59 ±0.1Vdc	---
-S	25	10.0 ±0.5Vdc	---
14	19	0.83 ±0.1Vdc	---
-S	A6	0.04 ±0.1Vdc	---
-S	8	0.45 ±0.07Vdc	---
10	-S	0.06 ±0.1Vdc	---
19	-S	0.82 ±0.1Vdc	---
15	19	1.14 ±0.2Vdc	---
33	16	0.74 ±0.1Vdc	---
33	36	0.8 ±0.1Vdc	---
41	42	46.0 ±2.3Vpp	---
28	33	66.0 ±3.3Vpp	---
33	38	14.0 ±1.4Vdc	---

NOTE

These measurements were made with a 115 Volt, 60Hz, single-phase power input; the front-panel CURRENT controls fully clockwise (maximum); the front-panel VOLTAGE controls set for 40Vdc output; and the 1.6 ohm load resistor across the output terminals (25 Amperes). Differential voltmeter hp 741A was used for all measurements.

5-39 TROUBLE ANALYSIS

5-40 GENERAL. Before attempting trouble analysis, a good understanding of the principles of operation should be acquired by reading Section IV of this manual. Once the principles of operation are understood, logical application of this knowledge in conjunction with significant waveforms (on Figure 4-2) and with normal voltage information (Table 5-2) should suffice to isolate a fault to a part or small group of parts. As additional aids, the following are given:

a. Procedure for checking the bias and reference circuit. (Refer to Paragraph 5-42.) Trouble in this circuit could show up in many ways because it supplies internal operating voltages for the power supply and the programming currents.

b. Procedures for checking the voltage feedback loop for the two most common troubles; high or low output voltage (Paragraph 5-43 or 5-44, respectively).

c. Paragraph 5-45 which discusses common troubles.

5-41 A defective part should be replaced (refer to the parts list in Section VI). Test points called out in the procedures are identified on the schematic diagram (Figure 4-2).

5-42 BIAS AND REFERENCE CIRCUIT. Proceed as follows:

a. Make an ohmmeter check to be certain that neither the positive nor negative terminal is grounded.

b. Turn front-panel VOLTAGE and CURRENT controls fully clockwise (maximum).

c. Turn-on power supply (no load connected).

d. Using the ac voltmeter, check voltage across secondary winding 5-6 of transformer T2. If voltage indication is not 23 ±1.5Vrms, transformer T2 may be defective.

e. Using the differential voltmeter, proceed as instructed in Table 5-3.

Table 5-3. Bias and Reference Circuit Troubleshooting

Step	Meter Common	Meter Positive	Normal Indication	If Indication is Not Normal, Check the Following Parts
1	33	40	33 ±1.7Vdc	CR31, C21
2	-S	33	6.2 ±0.3Vdc	CR6, CR14, VR4
3	27	33	34.1 ±1.7Vdc	CR30, C20
4	51	-S	19.5 ±1.0Vdc	Q10, Q11
5	51	24	10.3 ±0.6Vdc	CR27, VR3
6	51	22	9.7 ±0.5Vdc	R40, R43, Q6
7	51	21	9.7 ±0.5Vdc	R38, R42, Q5

Table 5-4. High Output Voltage Troubleshooting

Step	Meter Common	Meter Positive	Response	Probable Cause
1	Emitter of Q4	29	<0.5Vdc	a. Q4 shorted b. R16 shorted c. R15 shorted
2	14	17	>0.85Vdc	CR7 open
3	14	33	<2Vdc	a. Q1 open b. Q2 shorted c. CR1 shorted d. R2-R8 open

Table 5-5. Low Output Voltage Troubleshooting

Step	Meter Common	Meter Positive	Response	Probable Cause
1	Emitter of Q4	29	>5Vdc	a. Q4 open b. R16 open c. R15 open
2	14	17	<0.4Vdc	CR7 shorted
3	14	33	>6Vdc	a. Q1 shorted b. Q2 open c. R2-R8 shorted

5-43 HIGH OUTPUT VOLTAGE. Proceed as follows:

a. Turn front-panel CURRENT controls fully clockwise (maximum).

b. Turn front-panel VOLTAGE controls to mid-position.

c. Turn-on power supply (no load connected).

d. Using the ac voltmeter, check voltage across test points ACC and 45. If voltage indication is less than 1.0Vdc, CR17 or CR18 may be shorted.

e. Using the differential voltmeter, check voltage across test points 33 and 36. If voltage is not 0.8 ±0.12Vdc, check T2, CR39 through CR43, R50, and R51.

f. Using the differential voltmeter, proceed as instructed in Table 5-4.

5-44 LOW OUTPUT VOLTAGE. Proceed as follows:

a. Turn front-panel CURRENT controls fully clockwise (maximum).

b. Disconnect anode or cathode of diode CR8.

c. Turn-on power supply (no load connected).

d. Turn front-panel VOLTAGE controls clockwise and observe the front-panel voltmeter to see if the 40Vdc output can be obtained. If it can, the probable cause of the low output voltage is one or more of the following:

(1) CR8 shorted.
(2) Q8 shorted.
(3) Q9 open.
(4) Q6 open.
(5) R40, R43 open.

e. If the 40Vdc output cannot be obtained in step d, reconnect diode CR8 and turn the front-panel VOLTAGE controls to mid-position.

f. Using the oscilloscope, check the following:

(1) Waveform across test points 31 (positive lead) and 33 (waveform on Figure 4-2). If peak negative voltage is less than 15 Volts, Q7, R53, CR48, C25, C26, or transformer T3 may be defective. It is also possible that thermostat TS1 has opened due to excessive heat.

(2) Ripple waveform across test points 18 (positive lead) and 48 (waveform shown on Figure 4-2). If waveform is correct (except for amplitude), proceed to step (3). If waveform is incorrect, proceed as follows:

(a) If the ripple waveform is half-wave (60Hz) instead of full-wave (120Hz), either SCR (CR17 or CR18) may be open or the applicable gate circuit for the SCR may be defective. To check the gate circuit, disconnect R54 or R55 (as applicable) and make an ohmmeter check from the open end of the resistor to test point ACC or 45 (as applicable). If the resistance is greater than 55 ohms, the gate circuit is defective.

(b) If the ripple waveform indicates that neither SCR has fired, CR17 or CR18 may be shorted.

(c) If there is no ripple waveform, both CR17 and CR18 may be open or T1 may be defective.

g. Using the differential voltmeter, proceed as instructed in Table 5-5.

5-45 COMMON TROUBLES. Table 5-6 gives the symptoms, checks, and probable causes for common troubles. The checks should be made using a 115-volt, 60Hz, single-phase power input and the test equipment listed in Table 5-1.

Table 5-6. Common Troubles

Symptom	Checks and Probable Causes
Circuit breaker CB1 trips when power supply is turned on.	Power supply has internal short. Disconnect collector of Q7, turn-on power supply and check voltages (refer to Table 5-2 or Figure 4-2). If CB1 trips with Q7 disconnected, check CR17, CR18, and T3.
Poor line regulation (constant voltage)	a. Check bias and reference circuit (Paragraph 5-42). Refer to Paragraph 5-66 for adjustment. b. Check line input to SCR regulator control circuit (T2, CR39 through CR43, R50, R51).
Poor load regulation (constant voltage)	a. Check bias and reference circuit (Paragraph 5-42). b. Power supply going into current limit. Check constant current input circuit. c. Constant voltage loop oscillates. Check adjustment of R17 (Paragraph 5-68).

Table 5-6. Common Troubles (Continued)

Symptom	Checks and Probable Cause
Poor line and load regulation (constant current)	a. Check bias and reference circuit (Paragraph 5-42). Refer to Paragraph 5-66 for adjustment. b. Power supply going into voltage limit. Check constant voltage input circuit. c. Constant current loop oscillates. Check adjustment of R44 (Paragraph 5-70).
High ripple	a. Check operating setup for ground loops. b. If output is floating (ungrounded) connect 1μf capacitor between output and ground (unless particular application prohibits this). c. Check pi-section output filter C13 through C17 and L1. d. Line imbalance. Check adjustment of R17 (Paragraph 5-67).
Poor stability (constant voltage)	a. Check bias and reference circuit line regulation. (Refer to Paragraph 5-66.) b. Noisy programming resistors (R2-R8). c. CR1 or CR2 leaky. d. R1, R5, R40, R41, or R43 noisy or drifting. e. Q1 or Q2 defective.
Poor stability (constant current)	a. Check bias and reference circuit line regulation. (Refer to Paragraph 5-66). b. Noisy programming resistors (R9-R10). c. R20, R23, R38, R39, or R42 noisy or drifting. d. Q8 defective.
Oscillates (constant voltage)	Check R18, C1, C4, and adjustment of R17 (Paragraph 5-68).
Oscillates (constant current)	Check C6, C24, R22, and adjustment or R20 (Paragraph 5-63) and adjustment of R44 (Paragraph 5-69).
Output voltage does not go to zero.	Check R6 and R47. (Refer to Paragraph 5-60.)
Output current does not go to zero.	Check R20 and R46. (Refer to Paragraph 5-64.)

5-46 REPAIR AND REPLACEMENT

5-47 Before servicing etched circuit boards, refer to Figure 5-7. After replacing a semiconductor device, refer to Table 5-7 for checks and adjustments that may be necessary. If a check indicates a trouble, refer to Paragraph 5-36. If an adjustment is necessary, refer to Paragraph 5-48.

Excessive heat or pressure can lift the copper strip from the board. Avoid damage by using a low power soldering iron (50 watts maximum) and following these instructions. Copper that lifts off the board should be cemented in place with a quick drying acetate base cement having good electrical insulating properties.

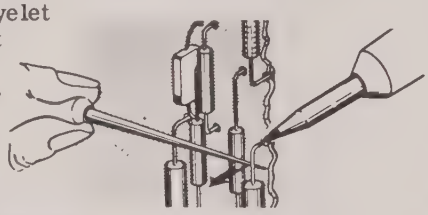
A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

Use only high quality rosin core solder when repairing etched circuit boards. NEVER USE PASTE FLUX. After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or lacquer.

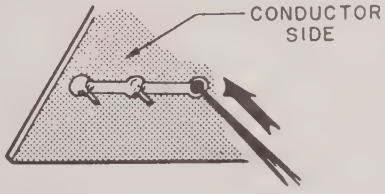
When replacing components with multiple mounting pins such as tube sockets, electrolytic capacitors, and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

WARNING: If the specific instructions outlined in the steps below regarding etched circuit boards without eyelets are not followed, extensive damage to the etched circuit board will result.

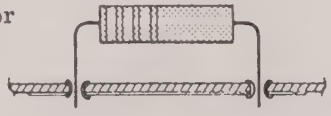
1. Apply heat sparingly to lead of component to be replaced. If lead of component passes through an eyelet in the circuit board, apply heat on component side of board. If lead of component does not pass through an eyelet, apply heat to conductor side of board.



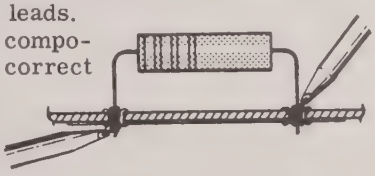
2. Reheat solder in vacant eyelet and quickly insert a small awl to clean inside of hole. If hole does not have an eyelet, insert awl or a #57 drill from conductor side of board.



3. Bend clean tinned lead on new part and carefully insert through eyelets or holes in board.

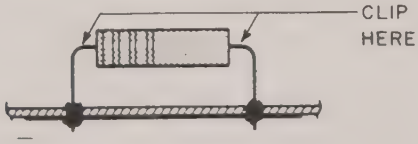


4. Hold part against board (avoid overheating) and solder leads. Apply heat to component leads on correct side of board as explained in step 1.

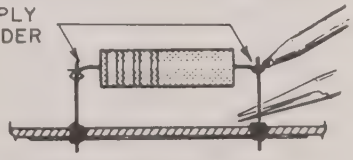


In the event that either the circuit board has been damaged or the conventional method is impractical, use method shown below. This is especially applicable for circuit boards without eyelets.

1. Clip lead as shown below.



2. Bend protruding leads upward. Bend lead of new component around protruding lead. Apply solder using a pair of long nose pliers as a heat sink.



This procedure is used in the field only as an alternate means of repair. It is not used within the factory.

Figure 5-7. Servicing Printed Wiring Boards

Table 5-7. Checks and Adjustments after Replacement of Semiconductor Devices

Circuit Reference	Function	Check	Adjust
Q1, Q2	Constant voltage differential amplifier	Constant voltage line and load regulation; transient recovery time; zero voltage output	R6, R17
Q3	Turn-on circuit	Excessive transients at turn-on	--
Q4	Gating Circuit	Constant voltage/constant current line and load regulation	--
Q5	Constant voltage programming current regulator	Constant voltage programming coefficient	R38-R39
Q6	Constant current programming current regulator	Constant current programming coefficient	R40-R41
Q7	SCR regulator control	Waveforms (shown on schematic diagram at rear of manual	R51
Q8, Q9	Constant current differential amplifier	Constant current line and load regulation; zero current output	R20, R44
Q10	Bias and reference error detector/amplifier	Bias and reference circuit line regulation	R45
Q11	Bias and reference series regulator	Bias and reference circuit line regulation	R45
CR1, CR2, CR28	Constant voltage protection	Constant voltage load regulation	--
CR6, CR9, CR10, CR11, CR12, CR14, CR27, CR46	Forward bias regulators	Voltage across each diode (0.6 to 0.85Vdc)	--
CR17, CR18	SCR regulator	Constant voltage load regulation	--
CR19, CR20 CR21, CR22	Bridge rectifier	Voltage across bridge at full output (18Vdc)	--
CR23	Output Protection	Output voltage	--
CR26	Constant current protection	Constant current line and load regulation	--
CR30, CR31	Full-wave rectifier	Rectifier output (67Vdc)	--
CR39, CR40 CR41, CR42 CR43	Bridge rectifier	Voltage across bridge (20-25 peak, full wave)	--

Table 5-7. Checks and Adjustments after Replacement of Semiconductor Devices (Continued)

Circuit Reference	Function	Check	Adjust
CR5, CR7, CR8, CR44, CR45, CR47, CR48, CR49, CR50, CR51	Diode switches	--	--
VR1	Constant voltage programming protection	Full output voltage and zero output voltage obtainable via VOLTAGE controls; voltage regulation at 18Vdc output	--
VR3	Voltage reference	Bias and reference circuit line regulation	R45
VR4	Voltage reference	6.0Vdc line regulation	--

5-48 ADJUSTMENTS AND CALIBRATIONS

5-49 GENERAL

5-50 Adjustments and calibrations may be required after performance testing (Paragraph 5-7), additional specification testing (Paragraph 5-23), troubleshooting (Paragraph 5-36), or repair and replacement (Paragraph 5-50). Test points called out in the procedures are identified on the schematic diagram (Figure 4-2). If an adjustment or calibration cannot be performed, troubleshooting is required. Table 5-8 summarizes the adjustments and calibrations. The adjustments and calibrations are performed using a 115-volt, 60Hz, single-phase power input to the power supply.

5-51 METER ZERO

5-52 Proceed as follows:

a. Turn-off power supply and allow 2 minutes for all capacitors to discharge.

b. Rotate voltmeter zero-set screw (Figure 3-1) clockwise until the meter pointer is to the right of zero and moving to the left towards zero. Stop when pointer is on zero. If the pointer overshoots zero, continue rotating clockwise and repeat this step.

Table 5-8. Adjustment and Calibration Summary

Adjustment or Calibration	Paragraph Reference	Control Device
Meter Zero	5-52	Meter Spring
Voltmeter Tracking	5-54	R25
Ammeter Tracking	5-56	R27
Constant Voltage Programming Current	5-58	R39
Zero Voltage Output	5-60	R6
Constant Current Programming Current	5-62	R41
Zero Current Output	5-64	R20
Bias and Reference Line Regulation	5-66	R45
Line Imbalance	5-68	R17
Constant Current Load Regulation	5-70	R44

c. When the pointer is exactly on zero, rotate the zero-set screw counterclockwise approximately 15 degrees to free the screw from the meter suspension. If pointer moves, repeat steps a through c.

d. Repeat steps a through c for the ammeter.

5-53 VOLTMETER TRACKING

5-54 Proceed as follows:

a. Connect the differential voltmeter across -S and +S terminals.

b. Turn front-panel VOLTAGE controls until the differential voltmeter indicates 40Vdc.

c. Adjust R25 until the front-panel voltmeter indicates 40Vdc.

5-55 AMMETER TRACKING

5-56 Proceed as follows:

a. Connect test setup shown in Figure 5-3.

b. Turn front-panel VOLTAGE controls fully clockwise (maximum).

c. Turn front-panel CURRENT controls until the differential voltmeter indicates 0.5V.

d. Adjust R27 until the front-panel ammeter indicates 25 Amperes.

5-57 CONSTANT VOLTAGE PROGRAMMING CURRENT

5-58 Proceed as follows:

a. Connect a 8,000 ohm, 0.1%, 1/2W resistor between terminals +S and A6 on the rear terminal strip of the power supply.

b. Disconnect the jumper between terminals A6 and A7.

c. Connect the resistance box in place of R39 (shunt).

d. Connect the differential voltmeter between the +S and -S terminals.

e. Adjust the resistance box until the differential voltmeter indicates 40 ±0.2Vdc.

f. Choose resistor R39 (shunt) equal to the resistance required in step e.

5-59 ZERO VOLTAGE OUTPUT

5-60 Proceed as follows:

a. Connect a jumper between the +S and A7 terminals on the rear terminal strip of the power supply.

b. Connect the differential voltmeter between the +S and -S terminals.

c. Connect the resistance box in place of R6.

d. Adjust the resistance box so that the voltage indicated by the differential voltmeter is between zero and ±10 mVdc.

e. Choose resistor R6 equal to the resistance value required in step d.

5-61 CONSTANT CURRENT PROGRAMMING CURRENT

5-62 Proceed as follows:

a. Connect test setup shown in Figure 5-3.

b. Connect a 250 ohm, 0.1%, 1/2W resistor between terminals A2 and A3 on the rear terminal strip of the power supply.

c. Disconnect the jumper between terminals A1 and A2.

d. Connect the resistance box in place of R41 (shunt).

e. Adjust the resistance box until the differential voltmeter indicates 25 ±2.5 mVdc.

f. Choose resistor R41 (shunt) equal to the resistance value required in step e.

5-63 ZERO CURRENT OUTPUT

5-64 Proceed as follows:

a. Connect test setup shown in Figure 5-3.

b. Connect a jumper between the A1 and A3 terminals on the rear terminal strip of the power supply.

c. Connect the resistance box in place of R20.

d. Adust the resistance box until the voltage indicated by the differential voltmeter is between zero and 0.1 mVdc.

e. Choose resistor R20 equal to the resistance value required in step d.

NOTE

If the resistance value required is less than 7,000 ohms or greater than 17,000 ohms, change R46. Replace the original R20.

5-65 BIAS AND REFERENCE LINE REGULATION

5-66 Proceed as follows:

a. Connect the variable voltage transformer between the input power source and the power supply power input. Adjust the variable voltage transformer to 105Vac.

b. Connect the differential voltmeter between the +S and -S terminals.

c. Connect the resistance box in place of R45.

d. Turn front-panel VOLTAGE controls until the differential voltmeter indicates 40Vdc.

e. Adjust the variable voltage transformer to 125Vac.

f. Adjust the resistance box until the voltage indicated by the differential voltmeter is within 18 mVdc of 40Vdc.

g. Choose resistor R45 equal to the resistance value required in step f.

NOTE

If the resistance value required is less than 20,000 ohms, troubleshooting is required. Replace the original R45.

5-67 LINE IMBALANCE

5-68 Proceed as follows:

a. Connect the 1.6 ohm load resistor across the output terminals.

b. Turn front-panel CURRENT controls fully clockwise (maximum).

c. Connect the variable voltage transformer between the input power source and the power supply power input. Adjust the variable voltage transformer to 125Vac.

d. Turn front-panel VOLTAGE controls until front-panel ammeter indicates 25 Amperes.

e. Connect the oscilloscope across test points 18 and 48. Use internal sync.

f. Connect the resistance box in place of R17.

g. Adjust the resistance box until the oscilloscope display is similar to the waveform for test points 18-48 shown on Figure 4-2.

h. Choose resistor R17 equal to the resistance value required in step f.

NOTE

If the resistance value required is less than 5,000 ohms, troubleshooting is required. Replace the original R17.

5-69 CONSTANT CURRENT LOAD REGULATION

5-70 Proceed as follows:

a. Perform steps a through e of Paragraph 5-18.

b. Place a 10-megohm resistor in place of R44.

c. Adjust the variable voltage transformer to 125Vac.

d. Close the shorting switch.

e. Differential voltmeter indication should change by less than 4.0 mVdc. If voltage change is greater than 4.0 mVdc, reduce the 10-megohm resistor to 9 megohms, set the variable voltage transformer to 105Vac, open the shorting switch, record the differential voltmeter indication, and repeat steps c and d. Repeat this process, reducing the 10-megohm resistor in 1-megohm steps until the voltmeter change is less than 4.0 mVdc. Changes smaller than 1-megohm may be required to obtain the optimum resistance value for R44. Choose resistor R44 equal to the optimum resistance value required.

NOTE

If the resistance value required is less than 1 megohm, troubleshooting is required. Replace the original R44.

SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts. Table 6-4 lists parts in alphanumeric order by reference designators and provides the following information:

a. Reference Designators. Refer to Table 6-1.

b. Description. Refer to Table 6-2 for abbreviations.

c. Total Quantity (TQ). Given only the first time the part number is listed except in instruments containing many sub-modular assemblies, in which case the TQ appears the first time the part number is listed in each assembly.

d. Manufacturer's Part Number or Type.

e. Manufacturer's Federal Supply Code Number. Refer to Table 6-3 for manufacturer's name and address.

f. Hewlett-Packard Part Number.

g. Recommended Spare Parts Quantity (RS) for complete maintenance of one instrument during one year of isolated service.

h. Parts not identified by a reference designator are listed at the end of Table 6-4 under Mechanical and/or Miscellaneous. The former consists of parts belonging to and grouped by individual assemblies; the latter consists of all parts not immediately associated with an assembly.

6-3 ORDERING INFORMATION

6-4 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses). Specify the following information for each part: Model, complete serial number, and any Option or special modification (J) numbers of the instrument; Hewlett-Packard part number; circuit reference designator; and description. To order a part not listed in Table 6-4, give a complete description of the part, its function, and its location.

Table 6-1. Reference Designators

A	= assembly	E	= miscellaneous electronic part
B	= blower (fan)	F	= fuse
C	= capacitor	J	= jack, jumper
CB	= circuit breaker	K	= relay
CR	= diode	L	= inductor
DS	= device, signaling (lamp)	M	= meter

Table 6-1. Reference Designators (Continued)

P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
Q	= transistor		
R	= resistor	VR	= zener diode
S	= switch	X	= socket
T	= transformer	Z	= integrated circuit or network
TB	= terminal block		
TS	= thermal switch		

Table 6-2. Description Abbreviations

A	= ampere	mfr	= manufacturer
ac	= alternating current	mod.	= modular or modified
assy.	= assembly	mtg	= mounting
bd	= board	n	= nano = 10^{-9}
bkt	= bracket	NC	= normally closed
°C	= degree Centigrade	NO	= normally open
		NP	= nickel-plated
cd	= card	Ω	= ohm
coef	= coefficient	obd	= order by description
comp	= composition		
CRT	= cathode-ray tube	OD	= outside diameter
CT	= center-tapped	p	= pico = 10^{-12}
dc	= direct current	P.C.	= printed circuit
DPDT	= double pole, double throw	pot.	= potentiometer
		p-p	= peak-to-peak
DPST	= double pole, single throw	ppm	= parts per million
elect	= electrolytic	pvr	= peak reverse voltage
encap	= encapsulated		
F	= farad	rect	= rectifier
°F	= degree Farenheit	rms	= root mean square
fxd	= fixed	Si	= silicon
Ge	= germanium	SPDT	= single pole, double throw
H	= Henry		
Hz	= Hertz	SPST	= single pole, single throw
IC	= integrated circuit	SS	= small signal
ID	= inside diameter	T	= slow-blow
incnd	= incandescent	tan.	= tantulum
k	= kilo = 10^{3}	Ti	= titanium
m	= milli = 10^{-3}	V	= volt
M	= mega = 10^{6}	var	= variable
μ	= micro = 10^{-6}	ww	= wirewound
met.	= metal	W	= Watt

Table 6-3. Code List of Manufacturers

CODE NO.	MANUFACTURER	ADDRESS
00629	EBY Sales Co., Inc.	Jamaica, N.Y.
00656	Aerovox Corp.	New Bedford, Mass.
00853	Sangamo Electric Co. S. Carolina Div.	Pickens, S.C.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Semiconductor-Components Div.	Dallas, Texas
01686	RCL Electronics, Inc.	Manchester, N.H.
01930	Amerock Corp.	Rockford, Ill.
02107	Sparta Mfg. Co.	Dover, Ohio
02114	Ferroxcube Corp.	Saugerties, N.Y.
02606	Fenwal Laboratories	Morton Grove, Ill.
02660	Amphenol Corp.	Broadview, Ill.
02735	Radio Corp. of America, Solid State and Receiving Tube Div.	Somerville, N.J.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co. Inc.	Cedar Knolls, N.J.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
04072	ADC Electronics, Inc.	Harbor City, Calif.
04213	Caddell & Burns Mfg. Co. Inc.	Mineola, N.Y.
04404	*Hewlett-Packard Co. Palo Alto Div.	Palo Alto, Calif.
04713	Motorola Semiconductor Prod. Inc.	Phoenix, Arizona
05277	Westinghouse Electric Corp. Semiconductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	Grand Junction, Colo.
05820	Wakefield Engr. Inc.	Wakefield, Mass.
06001	General Elect. Co. Electronic Capacitor & Battery Dept.	Irmo, S.C.
06004	Bassik Div. Stewart-Warner Corp.	Bridgeport, Conn.
06486	IRC Div. of TRW Inc. Semiconductor Plant	Lynn, Mass.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co.	Penacook, N.H.
06666	General Devices Co. Inc.	Indianapolis, Ind.
06751	Semcor Div. Components, Inc.	Phoenix, Arizona
06776	Robinson Nugent, Inc.	New Albany, Ind.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07263	Fairchild Camera and Instrument Corp. Semiconductor Div.	Mountain View, Calif.
07387	Birtcher Corp., The	Los Angeles, Calif.
07397	Sylvania Electric Prod. Inc. Sylvania Electronic Systems Western Div.	Mountain View, Calif.
07716	IRC Div. of TRW Inc. Burlington Plant	Burlington, Iowa
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Co. Components Div. Semiconductor Operation	Mountain View, Calif.
08484	Breeze Corporations, Inc.	Union, N.J.
08530	Reliance Mica Corp.	Brooklyn, N.Y.
08717	Sloan Company, The	Sun Valley, Calif.
08730	Vemaline Products Co. Inc.	Wyckoff, N.J.
08806	General Elect. Co. Miniature Lamp Dept.	Cleveland, Ohio
08863	Nylomatic Corp.	Norrisville, Pa.
08919	RCH Supply Co.	Vernon, Calif.
09021	Airco Speer Electronic Components	Bradford, Pa.
09182	*Hewlett-Packard Co. New Jersey Div.	Rockaway, N.J.
09213	General Elect. Co. Semiconductor Prod. Dept.	Buffalo, N.Y.
09214	General Elect. Co. Semiconductor Prod. Dept.	Auburn, N.Y.
09353	C & K Components Inc.	Newton, Mass.
09922	Burndy Corp.	Norwalk, Conn.
11115	Wagner Electric Corp. Tung-Sol Div.	Bloomfield, N.J.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of Cal. Inc.	So. Pasadena, Calif.
11502	IRC Div. of TRW Inc. Boone Plant	Boone, N.C.
11711	General Instrument Corp Rectifier Div.	Newark, N.J.
12136	Philadelphia Handle Co. Inc.	Camden, N.J.
12615	U.S. Terminals, Inc.	Cincinnati, Ohio
12617	Hamlin Inc.	Lake Mills, Wisconsin
12697	Clarostat Mfg. Co. Inc.	Dover, N.H.
13103	Thermalloy Co.	Dallas, Texas
14493	*Hewlett-Packard Co. Loveland Div.	Loveland, Colo.
14655	Cornell-Dubilier Electronics Div. Federal Pacific Electric Co.	Newark, N.J.
14936	General Instrument Corp. Semiconductor Prod. Group	Hicksville, N.Y.
15801	Fenwal Elect.	Framingham, Mass.
16299	Corning Glass Works, Electronic Components Div.	Raleigh, N.C.

*Use Code 28480 assigned to Hewlett-Packard Co., Palo Alto, California

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
16758	Delco Radio Div. of General Motors Corp.	Kokomo, Ind.
17545	Atlantic Semiconductors, Inc.	Asbury Park, N.J.
17803	Fairchild Camera and Instrument Corp Semiconductor Div. Transducer Plant	Mountain View, Calif.
17870	Daven Div. Thomas A. Edison Industries McGraw-Edison Co.	Orange, N.J.
18324	Signetics Corp.	Sunnyvale, Calif.
19315	Bendix Corp. The Navigation and Control Div.	Teterboro, N.J.
19701	Electra/Midland Corp.	Mineral Wells, Texas
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
22229	Union Carbide Corp. Electronics Div.	Mountain View, Calif.
22753	UID Electronics Corp.	Hollywood, Fla.
23936	Pamotor, Inc.	Pampa, Texas
24446	General Electric Co.	Schenectady, N.Y.
24455	General Electric Co. Lamp Div. of Consumer Prod. Group	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
24681	LTV Electrosystems Inc Memcor/Components Operations	Huntington, Ind.
26982	Dynacool Mfg. Co. Inc.	Saugerties, N.Y.
27014	National Semiconductor Corp.	Santa Clara, Calif.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
28875	IMC Magnetics Corp. New Hampshire Div.	Rochester, N.H.
31514	SAE Advance Packaging, Inc.	Santa Ana, Calif.
31827	Budwig Mfg. Co.	Ramona, Calif.
33173	G.E. Co. Tube Dept.	Owensboro, Ky.
35434	Lectrohm, Inc.	Chicago, Ill.
37942	P.R. Mallory & Co. Inc.	Indianapolis, Ind.
42190	Muter Co.	Chicago, Ill.
43334	New Departure-Hyatt Bearings Div. General Motors Corp.	Sandusky, Ohio
44655	Ohmite Manufacturing Co.	Skokie, Ill.
46384	Penn Engr. and Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
49956	Raytheon Co.	Lexington, Mass.
55026	Simpson Electric Co. Div. of American Gage and Machine Co.	Chicago, Ill.
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Electric Co.	Bristol, Conn.
58849	Syntron Div. of FMC Corp.	Homer City, Pa.
59730	Thomas and Betts Co.	Philadelphia, Pa.
61637	Union Carbide Corp.	New York, N.Y.
63743	Ward Leonard Electric Co.	Mt. Vernon, N.Y.

CODE NO.	MANUFACTURER	ADDRESS
70563	Amperite Co. Inc.	Union City, N.J.
70901	Beemer Engrg. Co.	Fort Washington, Pa.
70903	Belden Corp.	Chicago, Ill.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionic Corp.	Cambridge, Mass.
71400	Bussmann Mfg. Div. of McGraw & Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	I.T.T. Cannon Electric Inc.	Los Angeles, Calif.
71590	Globe-Union Inc. Centralab Div.	Milwaukee, Wis.
71700	General Cable Corp. Cornish Wire Co. Div.	Williamstown, Mass.
71707	Coto Coil Co. Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co. and Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co. Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72699	General Instrument Corp.	Newark, N.J.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72962	Elastic Stop Nut Div. of Amerace Esna Corp.	Union, N.J.
72982	Erie Technological Products Inc. Erie, Pa.	
73096	Hart Mfg. Co.	Hartford, Conn.
73138	Beckman Instruments Inc. Helipot Div.	Fullerton, Calif.
73168	Fenwal, Inc.	Ashland, Mass.
73293	Hughes Aircraft Co. Electron Dynamics Div.	Torrance, Calif.
73445	Amperex Electronic Corp.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73734	Federal Screw Products, Inc.	Chicago, Ill.
74193	Heinemann Electric Co.	Trenton, N.J.
74545	Hubbell Harvey Inc.	Bridgeport, Conn.
74868	Amphenol Corp. Amphenol RF Div.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	IRC Div. of TRW, Inc.	Philadelphia, Pa.
75183	*Howard B. Jones Div. of Cinch Mfg. Corp.	New York, N.Y.
75376	Kurz and Kasch, Inc.	Dayton, Ohio
75382	Kilka Electric Corp.	Mt. Vernon, N.Y.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76381	Minnesota Mining and Mfg. Co.	St. Paul, Minn.
76385	Minor Rubber Co. Inc.	Bloomfield, N.J.
76487	James Millen Mfg. Co. Inc.	Malden, Mass.
76493	J.W. Miller Co.	Compton, Calif.

*Use Code 71785 assigned to Cinch Mfg. Co., Chicago, Ill.

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
76530	Cinch	City of Industry, Calif.
76854	Oak Mfg. Co. Div. of Oak Electro/Netics Corp.	Crystal Lake, Ill.
77068	Bendix Corp., Electrodynamics Div.	No. Hollywood, Calif.
77122	Palnut Co.	Mountainside, N.J.
77147	Patton-MacGuyer Co.	Providence, R.I.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine and Foundry Co. Potter and Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Illinois Tool Works Inc. Shakeproof Div.	Elgin, Ill.
78452	Everlock Chicago, Inc.	Chicago, Ill.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78526	Stanwyck Winding Div. San Fernando Electric Mfg. Co. Inc.	Newburgh, N.Y.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78584	Stewart Stamping Corp.	Yonkers, N.Y.
79136	Waldes Kohinoor, Inc.	L.I.C., N.Y.
79307	Whitehead Metals Inc.	New York, N.Y.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Co.	Mt. Kisco, N.Y.
80031	Mepco Div. of Sessions Clock Co.	Morristown, N.J.
80294	Bourns, Inc.	Riverside, Calif.
81042	Howard Industries Div. of Msl Ind. Inc.	Racine, Wisc.
81073	Grayhill, Inc.	La Grange, Ill.
81483	International Rectifier Corp.	El Segundo, Calif.
81751	Columbus Electronics Corp.	Yonkers, N.Y.
82099	Goodyear Sundries & Mechanical Co. Inc.	New York, N.Y.
82142	Airco Speer Electronic Components	Du Bois, Pa.
82219	Sylvania Electric Products Inc. Electronic Tube Div. Receiving Tube Operations	Emporium, Pa.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls Inc. Control Products Group	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp. Electric Power Div.	Eatontown, N.J.
83330	Herman H. Smith, Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Div. of Amerace Esna Corp.	Brookfield, Mass.
83508	Grant Pulley and Hardware Co.	West Nyack, N.Y.
83594	Burroughs Corp. Electronic Components Div.	Plainfield, N.J.
83835	U.S. Radium Corp.	Morristown, N.J.
83877	Yardeny Laboratories, Inc.	New York, N.Y.
84171	Arco Electronics, Inc.	Great Neck, N.Y.
84411	TRW Capacitor Div.	Ogallala, Neb.
86684	RCA Corp. Electronic Components	Harrison, N.J.
86838	Rummel Fibre Co.	Newark, N.J.
87034	Marco & Oak Industries a Div. of Oak Electro/netics Corp.	Anaheim, Calif.
87216	Philco Corp. Lansdale Div.	Lansdale, Pa.
87585	Stockwell Rubber Co. Inc.	Philadelphia, Pa.
87929	Tower-Olschan Corp.	Bridgeport, Conn.
88140	Cutler-Hammer Inc. Power Distribution and Control Div. Lincoln Plant	Lincoln, Ill.
88245	Litton Precision Products Inc, USECO Div. Litton Industries	Van Nuys, Calif.
90634	Gulton Industries Inc.	Metuchen, N.J.
90763	United-Car Inc.	Chicago, Ill.
91345	Miller Dial and Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Neb.
91662	Elco Corp.	Willow Grove, Pa.
91929	Honeywell Inc. Div. Micro Switch	Freeport, Ill.
92825	Whitso, Inc.	Schiller Pk., Ill.
93332	Sylvania Electric Prod. Inc. Semiconductor Prod. Div.	Woburn, Mass.
93410	Essex Wire Corp. Stemco Controls Div.	Mansfield, Ohio
94144	Raytheon Co. Components Div. Ind. Components Oper.	Quincy, Mass.
94154	Wagner Electric Corp. Tung-Sol Div.	Livingston, N.J.
94222	Southco Inc.	Lester, Pa.
95263	Leecraft Mfg. Co. Inc.	L.I.C., N.Y.
95354	Methode Mfg. Co.	Rolling Meadows, Ill.
95712	Bendix Corp. Microwave Devices Div.	Franklin, Ind.
95987	Weckesser Co. Inc.	Chicago, Ill.
96791	Amphenol Corp. Amphenol Controls Div.	Janesville, Wis.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97702	IMC Magnetics Corp. Eastern Div.	Westbury, N.Y.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98410	ETC Inc.	Cleveland, Ohio
98978	International Electronic Research Corp.	Burbank, Calif.
99934	Renbrandt, Inc.	Boston, Mass.

Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	hp Stock No.	RS
C1, 4, 5	fxd, elect 5μf 65vdc	3	D33689	hp	09182	0180-1836	1
C2	fxd, elect 100μf 6vdc	1	30D107G0060B4	Sprague	56289	0180-1734	1
C3	fxd, film .0022μf 200vdc	1	192P22292	Sprague	56289	0160-0154	1
C6, 22, 25	fxd, elect 1μf 35vdc	3	150D105X9036A2	Sprague	56289	0180-0291	1
C7, 13, 23	NOT ASSIGNED	-	-	-	-	-	-
C8	fxd, film .01μf 200vdc	1	192P10392	Sprague	56289	0160-0161	1
C9, 10, 18, 19	fxd, paper .047μf 600vdc	4	160P47396	Sprague	56289	0160-0005	1
C11	fxd, paper .47μf 600vdc	1	161P47406	Sprague	56289	0160-2464	1
C12	fxd, paper .1μf 400vdc	1	160P10494	Sprague	56289	0160-0013	1
C14-17	fxd, elect 40,000μf 50vdc	4	D42343	hp	09182	0180-1931	1
C20, 21	fxd, elect 300μf 40vdc	2	34D307G040GJ4	Sprague	56289	0180-1805	1
C24	fxd, elect 68μf 15vdc	1	150D686X0015R2	Sprague	56289	0180-1835	1
C26, 27	fxd, film .082μf 200vdc	2	192P82392	Sprague	56289	0160-0167	1
C28, 29	fxd, film .22μf 80vdc	2	192P2249R8	Sprague	56289	0160-2453	1
CB1	Circuit Breaker 25 amp 250vac max.	1	Type AM33 Curve 5	Heineman	74193	2110-0213	1
CR1, 5, 7-11, 26, 28, 39-45, 47, 48	Diode, si. 200prv 200mw	18	1N485B	hp	09182	1901-0033	8
CR4, 13, 15, 16, 24, 25, 29, 32-38	NOT ASSIGNED	-	-	-	-	-	-
CR2, 3, 6, 12, 14, 27, 46, 49-51	Rect. si. 200ma 15prv	10	111S1	hp	09182	1901-0461	6
CR17, 18	SCR 25A 200prv	2	C 30 B	G. E.	03508	1884-0058	2
CR19, 20	Rect. si. 20A 100prv	2	A 40 A	G. E.	03508	1901-0322	2
CR21-23	Rect. si. 20A 100prv	3	A 41 A	G. E.	03508	1901-0324	3
CR30, 31	Rect. si. 500ma 200prv	2	1N3253	R. C. A.	20735	1901-0389	2
DS1	Indicator Light, neon	1	599-124	Drake	72765	1450-0048	1
L1	Inductor, 1 mh	1		hp	09182	9100-2188	1
L2	Choke - R. F. I.	1		hp	09182	9100-2169	1
Q1-6, 8, 9	SS NPN si.	8	4JX16A1014	G. E.	03508	1854-0071	6
Q7, 11	SS NPN si.	2	2N3417	G. E.	03508	1854-0087	2
Q10	SS PNP si.	1	2N2907A	Sprague	56289	1853-0099	1
R1	fxd, met. film 20KΩ ±1% 1/8w	1	Type CEA T-O	I. R. C.	07716	0757-0449	1
R2	var. ww 10KΩ ±5%	1		hp	09182	2100-1854	1
R3, 13	fxd, met. film 43KΩ ±1% 1/8w	2	Type CEA T-O	I. R. C.	07716	0698-5090	1
R4, 19	fxd, met. film 100KΩ ±1% 1/8w	2	Type CEA T-O	I. R. C.	07716	0757-0465	1
R5, 20	fxd, met. film 12KΩ ±1% 1/8w	2	Type CEA T-O	I. R. C.	07716	0698-5088	1
R6, 35, 36	fxd, met. film 3KΩ ±1% 1/8w	3	Type CEA T-O	I. R. C.	07716	0757-1093	1
R7	fxd, met. film 4.75KΩ ±1% 1/8w	1	Type CEA T-O	I. R. C.	07716	0757-0437	1
R8	var. ww 200Ω ±5%	1		hp	09182	2100-1856	1
R9	var. ww 10Ω ±5%	1		hp	09182	2100-1857	1
R10	var. ww 300Ω ±5%	1		hp	09182	2100-1848	1
R11	fxd, comp 3KΩ ±5% 1w	1	GB 3025	A. B.	01121	0689-3025	1
R12, 15	fxd, comp 680KΩ ±5% ½w	2	EB 6845	A. B.	01121	0686-6845	1
R14, 49, 57	NOT ASSIGNED	-	-	-	-	-	-
R16, 33	fxd, comp 1KΩ ±5% ½w	2	EB 1025	A. B.	01121	0686-1025	1

Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	hp Stock No.	RS
R17, 39, 41, 44, 45	fxd, comp SELECTED ±5% ½w	5	Type EB	A. B.	01121		1
R18, 34, 53	fxd, comp 10KΩ ±5% ½w	3	EB 1045	A. B.	01121	0686-1045	1
R21	fxd, comp 10Ω ±5% 1w	1	GB 1005	A. B.	01121	0689-1005	1
R22, 30, 50	fxd, comp 3KΩ ±5% ½w	3	EB 3025	A. B.	01121	0686-3025	1
R23, 32	fxd, ww .04Ω ±10% 40w	2		hp	09182	0811-1950	1
R24	fxd, comp 47KΩ ±5% ½w	1	EB 4735	A. B.	01121	0686-4735	1
R25	var. ww 5KΩ (Modify)	1	Type 110-F4	C. T. S.	11236	2100-1824	1
R26	fxd, met. film 365Ω ±1% ¼w	1	Type CEB T-O	I. R. C.	07716	0757-0723	1
R27	var. ww 250Ω (Modify)	1	Type 110-F4	C. T. S.	11236	2100-0439	1
R28	fxd, ww 100Ω ±5% 40w	1		hp	09182	0811-1969	1
R29	fxd, ww .62Ω ±5% 2w	1	Type BWH	I. R. C.	07716	0811-1759	1
R31, 58	fxd, comp 33KΩ ±5% ½w	2	EB 3335	A. B.	01121	0686-3335	1
R37	fxd, met. film 1KΩ ±1% ¼w	1	Type CEB T-O	I. R. C.	07716	0757-0338	1
R38	fxd, met. film 2KΩ ±1% ¼w	1	Type CEB T-O	I. R. C.	07716	0757-0739	1
R40	fxd, met. film 6. 2KΩ ±1% ¼w	1	Type CEB T-O	I. R. C.	07716	0698-5149	1
R42, 43	fxd, comp 1. 3KΩ ±5% ½w	2	EB 1325	A. B.	01121	0686-1325	1
R46	fxd, comp 15 MEGΩ ±5% ½w	1	EB 1565	A. B.	01121	0686-1565	1
R47	fxd, comp 1 MEGΩ ±5% ½w	1	EB 1055	A. B.	01121	0686-1055	1
R48	fxd, comp 43KΩ ±5% ½w	1	EB 4335	A. B.	01121	0686-4335	1
R51	fxd, comp 180Ω ±5% ½w	1	EB 1815	A. B.	01121	0686-1815	1
R52	fxd, met. ox 3KΩ ±5% 2w	1	Type C 42 S	Corning	16299	0698-3642	1
R54, 55	fxd, comp 47Ω ±5% ½w	2	EB 4705	A. B.	01121	0686-4705	1
R56	fxd, comp 39Ω ±5% ½w	1	EB 3905	A. B.	01121	0686-3905	1
T1	Power Transformer	1		hp	09182	9100-2187	1
T2	Bias Transformer	1		hp	09182	9100-1876	1
T3	Pulse Transformer	1		hp	09182	9100-1875	1
TS1	Thermal Switch, N. C. Open on Rise 167°F ±5°F Close on Fall 137°F ±10°F	1		hp	09182	0440-0042	1
VR1, 5	Diode, zener 23. 7V ±5%	2		hp	09182	1902-3256	2
VR2	NOT ASSIGNED	-	-	-	-	-	-
VR3	Diode, zener 9. 4V ±5%	1	1N2163A	Motorola	04713	1902-0763	1
VR4	Diode, zener 4. 22V ±5%	1		hp	09182	1902-3070	1
	Welding Ass'y, Chassis	1		hp	09182	5060-6114	
	Welding Ass'y, Rear Chassis	1		hp	09182	06428-60001	
	Cover	2		hp	09182	5000-6009	
	Bracket - P. C. Board	1		hp	09182	5000-6012	
	Bracket - P. C. Board	1		hp	09182	5000-6014	
	Capacitor Clamp	4		hp	09182	5000-6017	
	Front Panel	1		hp	09182	06434-60001	
	Bracket - Choke	2		hp	09182	06428-00002	
	Buss Bar	2		hp	09182	06428-00003	
	Cover - D. C. Barr Strip	1		hp	09182	06428-20001	
	Heat Sink - S. C. R.	1		hp	09182	5020-5501	
	Heat Sink - Rectifier	2		hp	09182	5020-5502	
	Handle 5¼"	2		hp	09182	5020-5512	
	Cover - A. C. Barr Strip	1		hp	09182	5020-5513	
	Assembly - P. C. Board (Includes Components)	1		hp	09182	06434-60020	
	Board - Printed Circuit (Blank)	1		hp	09182	5020-5521	
	Barrier Strip	1	602-5	Kulka	75382	0360-1220	1

Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	hp Stock No.	RS
	Barrier Strip (Modify)	1	602-3	Kulka	75382	0360-1213	1
	Barrier Strip	1		hp	09182	0360-1238	1
	Jumper	2	602J	Kulka	75382	0360-1280	1
	Jumper	5	422-13-11-013	Cinch	71785	0360-1143	1
	Meter $3\frac{1}{2}$" size SCALE 0-50V	1		hp	09182	1120-1173	1
	Meter $3\frac{1}{2}$" size SCALE 0-30A	1		hp	09182	1120-1175	1
	Bezel ($\frac{1}{4}$ MOD.)	2		hp	09182	4040-0296	1
	Spring	8		hp	09182	1460-0256	2
	Fastener	1	C17373-012-24B	Tinnerman	89032	0510-0123	1
	5 Way Binding Post (maroon)	1	DF 21 MN	Superior	58474	1510-0040	1
	5 Way Binding Post (black)	2	DF 21 BC	Superior	58474	1510-0039	1
	Rubber Bumpers	4	Type 2097W	Stockwell	87585	0403-0089	1
	Knob ($\frac{1}{4}$ insert pointer)	4		hp	09182	0370-0084	1
	Spacer, $\frac{1}{4}$ Hex. (Br. Cad. Pl.)	1	8-32 x $\frac{1}{2}$ lg.	hp	09182	0380-0136	1
	Motor - Fan	1		hp	09182	3140-0010	1
	Casting - Mach.	1		hp	09182	5243A-20A	1
	Blade - Fan	1	4LHB182B	hp	09182	3160-0034	1
	Captive Nut	4	CLA-632-2	Pem. Eng.	46384	0590-0393	
	Shoulder Washer - double	8		hp	09182	0340-0172	2
	Standoff - Insulator	1	17A1-A6	Whitso	92825	0360-1449	1
	Spacer, $\frac{1}{4}$ Hex. (Br. Cad. Pl.)	1	6-32 x 3/4 lg.	hp	09182	0380-0091	1
	Spacer, $\frac{1}{4}$ Hex. (Br. Cad. Pl.)	4	8-32 x 3/8 lg	hp	09182	0380-0718	1
	Spacer, $\frac{1}{4}$ Hex. (Br. Cad. Pl.)	4	8-32 x 5/8 lg.	hp	09182	0380-0723	1
	Spacer, Alum. #10 clear 3/8 D x 5/8 lg.	3	9323-A194	Amatom	06540	0380-0396	1
	Shoulder Washer - nylon $\frac{1}{4}$ I. D. x .630D x .090 thk.	1	Part of Kit #140A601G20	Westinghouse	05277	2190-0898	1
	Nut - Floating	4	C7931-1032-3B	Tinnerman	89032	0510-0012	1
	Fastener	25	C8091-632-24B	Tinnerman	89032	0510-0275	6
	Fastener	4	C8082-832-24B	Tinnerman	89032	0590-0709	1
	Fastener	4	C684-1024-24B	Tinnerman	89032	0590-0711	1
	Rubber Bumper blk. Durmo Hard 55/60	4	3066	Stockwell	87585	0403-0085	1
	Wafer - Mounting	1	H 4021	Union Car.	61637	0340-0175	1
	Cable Clamp $\frac{1}{4}$ I. D.	1	T4-4	Whitehead	79307	1400-0330	1

MANUAL CHANGES

Model 6434B DC Power Supply
Manual HP Part No. 06434-90001

Make all corrections in the manual according to errata below, then check the following table for your power supply serial number and enter any listed change(s) in the manual.

SERIAL		MAKE CHANGES
Prefix	Number	
ALL	-	Errata
9D	0481 - 0750	1
9D	0751 - 0795	1, 2
0G	0796 - 1010	1, 2, 3
0G	1011 - 1085	1, 2, 3, 4
1140A	1086 - 1195	1 thru 5
1140A	1196 - 1310	1 thru 6
1140A	1311 - up	1 thru 8

ERRATA:

(1) On Figures 3-2 through 3-11, change the (-) and (+) terminals on the long terminal strip to A8 and A9, respectively.
(2) On Figure 3-3 delete the wire connected to terminal (A9) and connect it to (+S).
(3) In Paragraph 2-12, add the following sentence: "The input power line should be fused for 25 Amps at 115Vac or 15 Amps at 230Vac to allow for current surges resulting from SCR firing".
(4) On Page 6-5, change the HP Part No. for CB1 to 2110-0213, and R2 to HP Part No. 2100-1854.
(5) In the Replaceable Parts Table (Page 6-7) add the parts for Options 17 and 18 as follows:
CR17, 18: SCR 35A 400prv, HP Part No. 1884-0058.
R21: fxd, comp 22Ω ±5% 1W, HP Part No. 0689-2205.
R58: fxd, met. ox. 75KΩ ±5% 2W, HP Part No. 0764-0027.
T1: Transformer, Power, HP Part No. 06434-80091.
T2: Transformer, Bias, HP Part No. 9100-2195.

On Page 3-3, in Paragraph 3-22, change the text to read:
"The resistance programming coefficient (fixed by the programming current) is 10 ohms per ampere (output current increases 1 ampere for each 10 ohms in series with the programming terminals)."

CHANGE 1:

In the Replaceable Parts Table, make the following changes:
R21: Change to 100Ω ±5% 2W, HP Part No. 0698-3620.
Fan Motor: Change to HP Part No. 3140-0052.

CHANGE 2:

On the Schematic Diagram and in the Replaceable Parts Table, change R17 from selected to 3.3K, ½W, ±5%, HP Part No. 0686-3325.

CHANGE 3:

In the Replaceable Parts Table, change inductor L2 to HP Part No. 5080-7151.

CHANGE 4:

The following changes are made to allow the power supply to operate with Option 27 (208Vac input) or Option 28 (230Vac input).

In the Replaceable Parts Table and on the schematic, make the following changes:
C7: Add C7, 1μF, 35V, HP Part No. 0180-0291.
C12: Change to .047μF, 600V, HP Part No. 0160-0005.
C26: Change to .22μF, 80V, HP Part No. 0160-2453.
CR24: Add CR24, Diode, Si, 200prv 200mW, HP Part No. 1901-0033.
R3 and R13: Change to 47.5k ±1%, 1/8W, HP Part No. 0757-0457.
R15: Change to 150k ±5%, ½W, HP Part No. 0686-1545.
R21: Change to 390Ω ±5%, 2W HP Part No. 0698-3633.
R32: Add R32, 12k, ±5% ½W, HP Part No. 0686-1235.
R49: Add R49, 2k, ±5% ½W, HP Part No. 0686-2025.
R56: Change to 270Ω ±5%, ½W, HP Part No. 0686-2715.
T1: Change to HP Part No. 06433-80092.
T2: Change to HP Part No. 9100-2195.
T3: Change to HP Part No. 5080-7176.

On the schematic diagram, the wiring of T1 and T2 and associated parts has been changed as shown on following page.

On the schematic diagram, make the following changes:
In the SCR Regulator Control Circuit: Remove R56 (connected between C28 at the junction of R50, CR41-CR43) and replace with a short circuit. Reconnect new R56 (changed to 270Ω) in series with the junction of CR41-CR43 (anodes) and the junction of C28, R50, CR44, and CR46.

In the Constant Voltage Input Circuit: Add C7 (1μF, 35V) in parallel with R18.

In the Constant Current Input Circuit: (1) Remove jumper and add R49 (2k) between C6 and R31; (2) Remove jumper and add R32 (12k) between base of Q8 and R43-A2 junction; (3) add CR24 between base of Q8 (cathode side) and A4.

208Vac (Option 27) and 230Vac (Option 28) operation.

If Option 27 or 28 is installed, change all references in the manual from 115Vac operation to the appropriate line voltage input.

In Chapter 2, add the following paragraph 2-19. CONNECTIONS FOR 208/230 VOLT OPERATION (Options 27 and 28, respectively)

T1 is rewired as follows:

Connection between terminals 1 and 3 is removed.

Connection between terminals 2 and 5 is removed.

Terminal 2 is connected to terminal 3.

For 208V (Option 27) only, the AC input connection to terminal 5 is removed and connected to terminal 4.

T2 is rewired:

The AC input connection to the "115V" terminal is removed and connected to the "208V" or "230V" terminal as applicable.

ERRATA:

In Paragraph 2-14, change the second sentence to: This instrument should be used with a three conductor power cable (prepared by the user) that has #12 AWG wire.

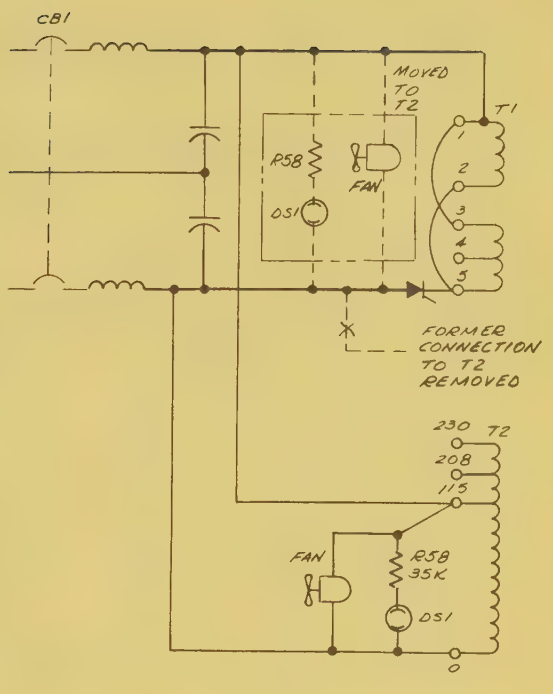
CHANGE 5:

The Serial Prefix of this unit has been changed to 1140A. This is the only change.

ERRATA:

The constant current resistance programming coefficient has been changed from 10 ohms/amp to 12 ohms/amp. In addition, the programming tolerance is now ±20%. Make the following change to reflect these new specifications:

Table 1-1: Change Remote Programming, Constant Current to 12 ohms per ampere ±20%.



Page 3-3, Paragraph 3-22: Line 4 now reads "current) is 12 ohms per ampere ... for each 12 ohms ...". Line 5 now reads "...approximately 20% of 1.66mA at the...".

Page 5-15, Paragraph 5-62

Step b: Change resistance to 300 ohms, 0.1%, $\frac{1}{2}$W resistor.

Step 3 (Page 5-16): Adjust resistance box until voltmeter indicates 25 ± 5mVdc.

CHANGE 6:

In the Replaceable Parts Table and on the schematic, change Resistor R46 to 10MΩ ±5%, $\frac{1}{2}$W, HP Part No. 0686-1065.

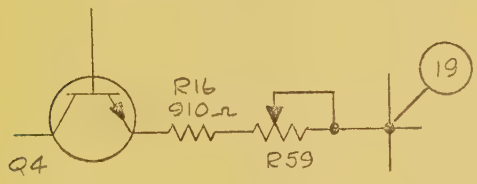
On Page 5-15, Paragraph 5-64, Step e and in the NOTE, change the reference to R20 to read "R6."

The standard colors for this instrument are now mint gray (for front and rear panels) and olive gray (for all top, bottom, side, and other external surfaces). Option X95 designates use of the former color scheme of light gray and blue gray. Option A85 designates use of a light gray front panel with olive gray used for all other external surfaces. New part numbers are shown at bottom.

DESCRIPTION	HP PART NO.		
	STANDARD	OPTION A85	OPTION X95
Front Panel, Lettered	06434-60003	06434-60001	See Manual Parts List
Cover	5000-9804	←	
Welding Assembly, Chassis	5060-7970	←	↓

CHANGE 7:

In the replaceable parts table and on the schematic, make the following changes:
R16: Change to 910Ω±5% 1/2W, HP Part No. 0686-9115.
R59: Add R59, Var WW 500Ω±5%, HP Part No. 2100-0898.
R59 is added in the Q4 Gating Circuit as follows:



R59 allows the Gating circuit clamp voltage to be adjusted in order to prevent half-cycle operation. In the factory, R59 is adjusted as follows: with supply set for full output voltage and current rating at low line, adjust R59 for a forward bias across CR9 of 150mV to 200mV.

CHANGE 8:

In the Replaceable Parts Table:
Change the HP Part No. of CR19 and CR20 from 1901-0322 to 1901-0317.
Change the HP Part No. of CR21-CR23 from 1901-0324 to 1901-0318.

▶ ERRATA:

On page 6-5 of the parts list, change the HP Part No. of circuit breaker CB1 to 3105-0034.

6-20-74

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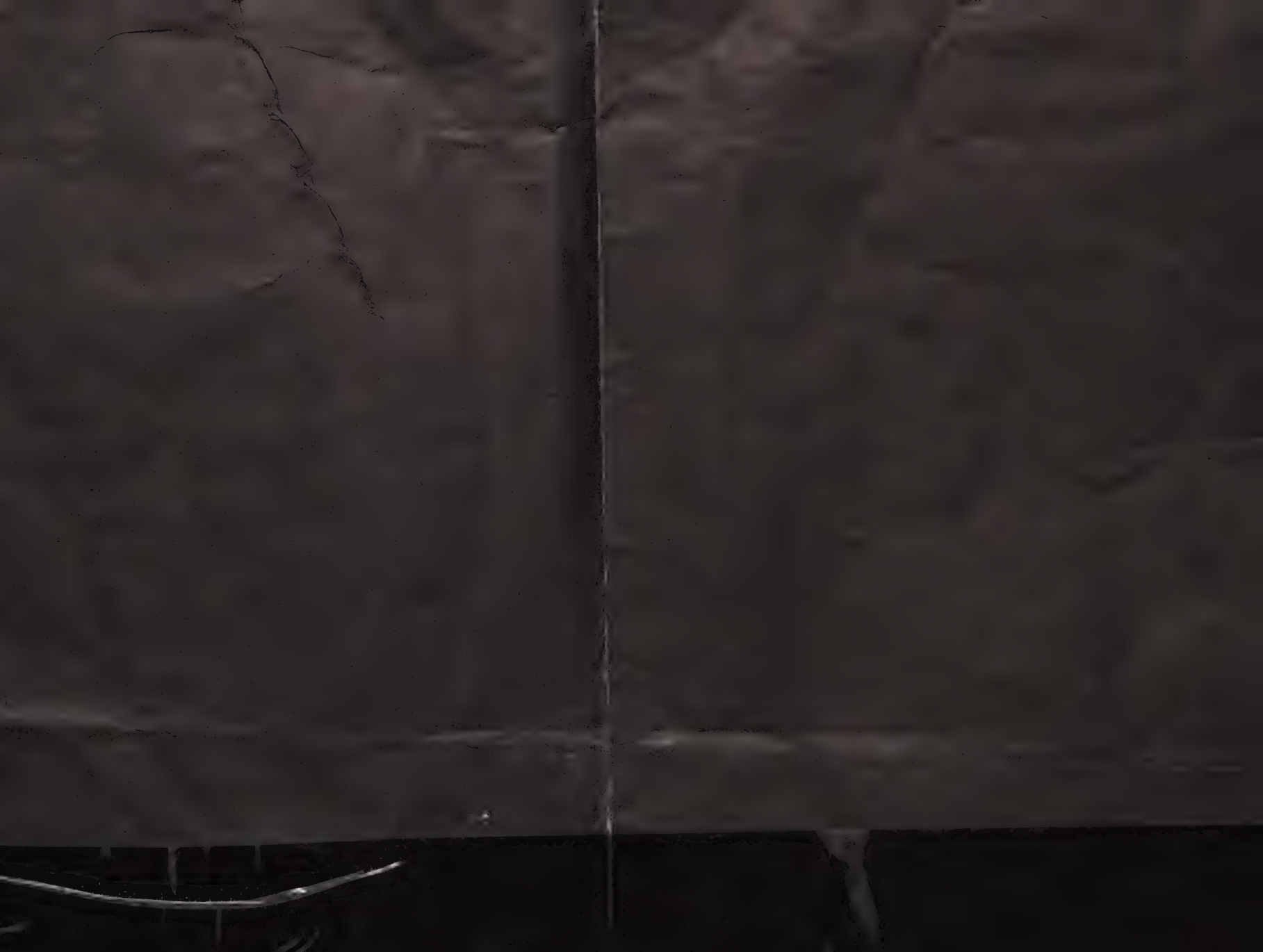
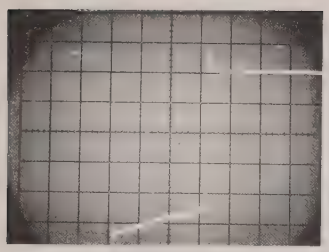
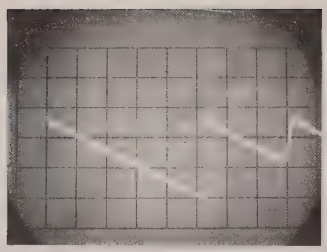
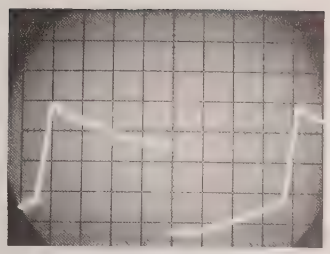




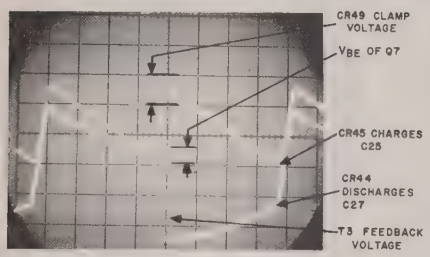
A. Test Points 31-33,
5μsec/cm, 5V/cm



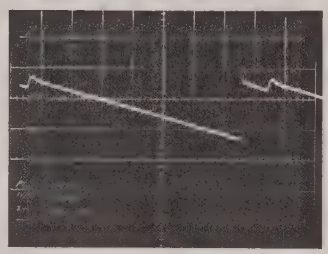
B. Test Points 29-33,
1ms/cm, 1V/cm



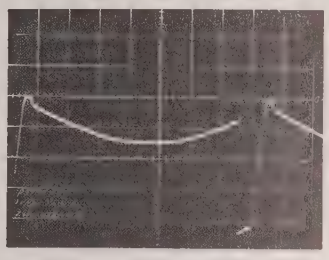
C. Test Points 37-33,
1ms/cm, 1V/cm



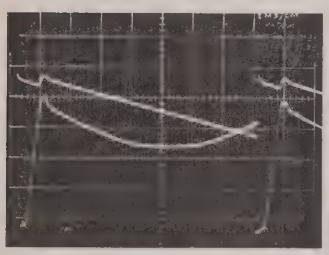
D. Waveforms B and C
Superimposed



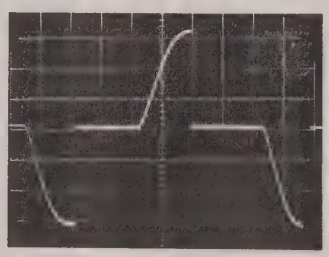
E. Same as B, Except Smaller
Load Used (2V, 3A)



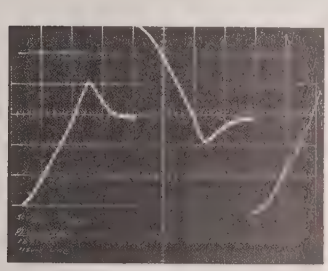
F. Same as C, Except Q7 Fires
Later Due to Smaller Load (2V, 3A)



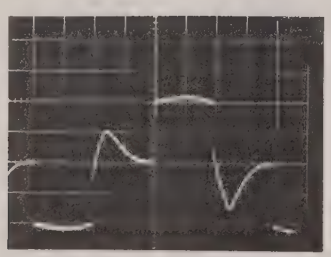
G. Waveforms E and F
Superimposed



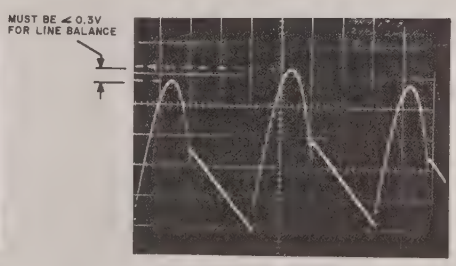
H. Test Points 45-ACC
2ms/cm, 50V/cm



I. Test Points 45-AC
2ms/cm, 50V/cm



J. Test Points 47-46
2ms/cm, 10V/cm

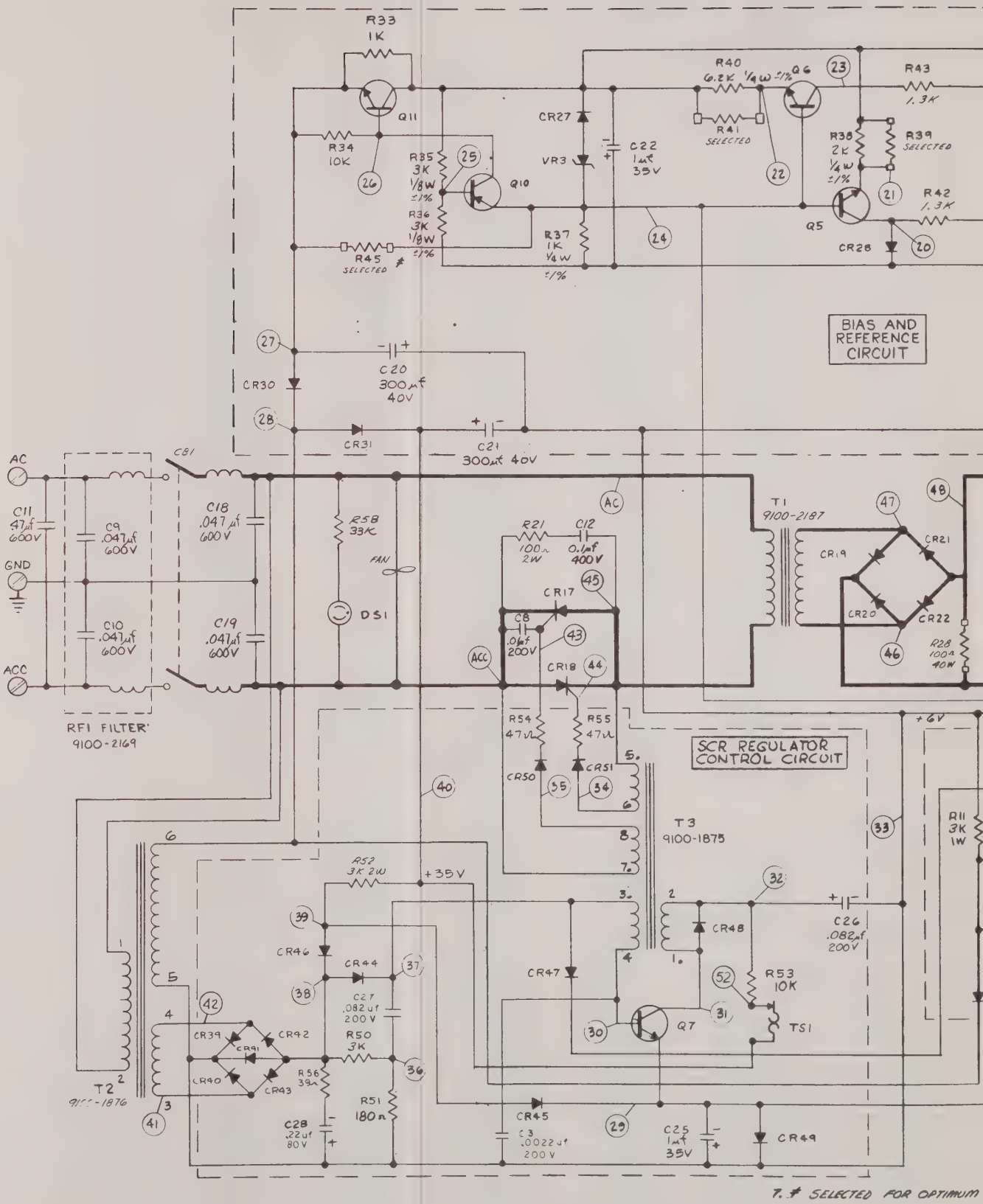


K. Test Points 48-18
2ms/cm, 0.2V/cm

All waveforms were taken with 115 Volt, 60Hz, single-phase input and 40Vdc, 25 Ampere load (except E and F as indicated). Waveforms H and I require the oscilloscope to be ungrounded. If it is not desirable to unground the oscilloscope, use a 1-kva isolation transformer between the input power source and the power supply power input.

WARNING

If the oscilloscope is ungrounded, injury can occur if personnel touch the oscilloscope case and other equipment simultaneously.



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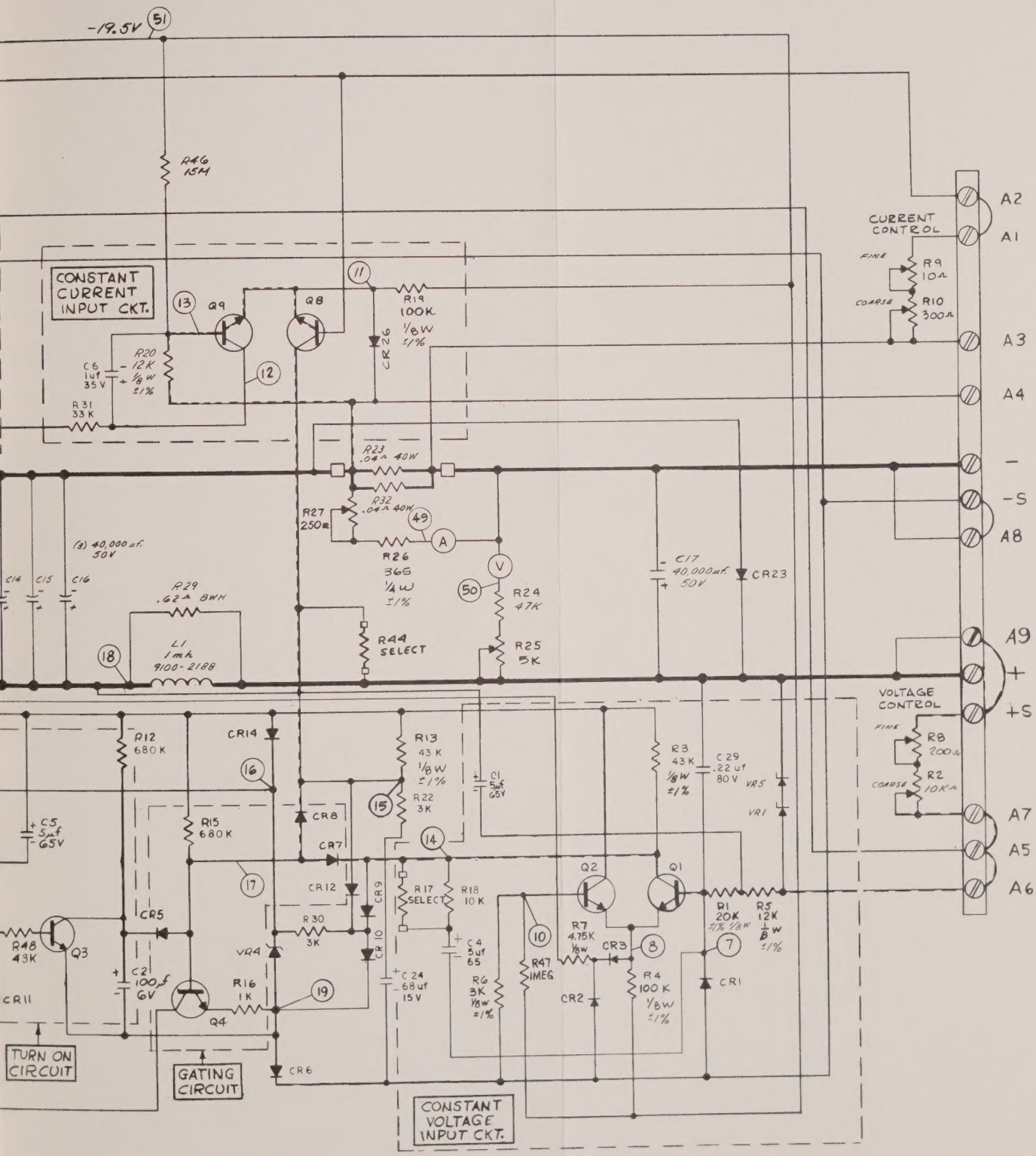

NOTES
PERFORMANCE

1. ALL RESISTORS ARE 1/2W. 5% UNLESS NOTED.
2. * DENOTES 20 PPM WIRE TEMP. COEFF.
3. REAR TERMINALS SHOWN IN NORMAL STRAPPING.
4. INPUT VOLTAGES MEASURED AT 115V. NO LOAD.
5. ——→ DENOTES VOLTAGE SIGNAL.
6. - - - - DENOTES CURRENT SIGNAL.

Schematic Diagram, Model 6434B

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